THE ART OF ORGAN VOICING

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L. G. Monette

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NEW ISSUES PRESS
WESTERN MICHIGAN UNIVERSITY
Kalamazoo, Michigan
1992

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Kalamazoo, MI 49008–3801

Library of Congress Cataloging-in-Publication Data

Monette, Louis G. (Louis Gayle)
The art of organ voicing / L.G. Monette.
p. cm.
Includes bibliographical references and index.
ISBN 0–932826–25–3 (hardbound) : $35.00
1. Organ-pipes. 2. Organ--Construction. I. Title.
ML595.M65 1992
786.5'192'3--dc20 92–23871
CIP
MN

Cover design by Linda K. Judy

Printed in the United States of America

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Preface

A decade has passed since the publication of *Organ Tonal Finishing and Fine Tuning*, a book in which Cj Stevens was my editor and ultimately my collaborator in bringing my manuscript through the process of publication. In the years since that book was written (and I should mention that there was considerable delay between its writing and its publication) I have continued to learn about my craft of organ building and voicing both from experience and from published scholarship on the subject of organs. There has been much of very great value published in recent years on this subject.

It came as no surprise to discover that I had written the only book in English about tonal finishing, for I was already familiar with the literature on organ construction and design. Nor did it particularly surprise me when I was told that I had written a history of tonal finishing as it was practiced by major builders during the middle years of the twentieth century, a practice that as I described it has virtually died out. It did surprise me, however, to learn that I had written the only extensive material of any consequence in English on the subject of voicing.

Dom Bédos writes about voicing in only two chapters of his *L'art du facteur d'orgues*, and these chapters have been translated. His material is accurate but sketchy, scarcely more than an expanded definition of the subject. In the twentieth century, Joseph Goebel has described the narrow field of neo-baroque voicing in his *Theorie und Praxis des Orgelpfeifenklanges*, but even this limited work is not available in English translation. I am aware of no other material specifically on the subject of voicing.

Organ Tonal Finishing and Fine Tuning, which was issued in an inexpensive edition, is now out of print, but I have learned that the book is still in demand by my colleagues. I assume that its principal interest involves the material on voicing since the rest of the book is not of any consequence to the practical organ builder, while the material on tuning is conveniently available in many other publications. In regard to what I wrote so many years ago, anyone who intends to use the system described in that book for tuning non-equal temperaments must adapt it to the temperament in question. For my own use I long ago simplified it for practicality. Today I must confess that I have entirely lost my ability to be charmed by music played in equal temperament. My preferences are for the temperaments such as Valotti-Young, Werckmeister III, and Kirnberger III over equal temperament except for the music of Max Reger and others of similar harmonic construction. After working with and listening to so many organs tuned to these and other temperaments, I now hear most music played in equal temperament as being equally cacophonous in all keys. I avoid using it whenever possible.

Over the past few years I have been encouraged by Clifford Davidson to publish additional material on the topic of voicing. In examining our original work some time ago, both Stevens and I decided that we did not want to re-issue the original book and that instead a thoroughly re-written discussion of voicing was needed. Since Stevens' death two years ago I have found no reason to alter my stand in this regard. Therefore this present book has been prepared under Davidson's careful editorial supervision. I am grateful for his interest and for the care with which this book has been produced.

Finally, I wish to express my gratitude to William C. Teague, Arthur Birchall, Donald Harrison, Allan van Zoeren, and Lawrence Phelps, each of whom influenced my professional development many years ago. This book is dedicated to them.

Sauk City, Wisconsin
September 1991

Introduction

Taste and Technique. It is not easy to describe the work of a voicer because the technical and the artistic sides of the task must be approached separately. The description of techniques poses no problem; the work is easily analyzed and outlined. The viewpoint of the artist, on the other hand, is harder to make plain because its subjectivity must be described in objective language and so far as possible entrusted to technical terminology. Opinions about voicing originate in musical and cultural tastes. These are matters that cannot be decided by majority vote, but rather the determination must ultimately be the test of time—that is, whether they survive over a long period of time.

The voicer determines how the organ sounds, but there are as many different approaches to organ sound as there are voicers. Sometime during one's professional life, each of us will decide what his preferences are. For example, I am aware that my tastes have changed over the course of my career and that organs which I once liked no longer are pleasing to me. I now prefer the sound of a single elegantly voiced stop which satisfies my ear and not the effect of massed ranks of stops played fast and loud in a reverberant room—just as I now prefer the spare lines of *The Art of Fugue* or the elegance of Mozart piano sonatas and not the emotional thunder of Romantic symphonies. Each voicer must sort out these things for himself to find his own taste. However, the techniques of working with pipes will fortunately encompass all opinions. Hence, since I am unable to describe the process of voicing without expressing my own opinions, I have tried to make allowances for others' tastes which differ from my own.

Great musical instruments are easily recognized by great musicians who play them. No one disputes that a violin by Antonio Stradivari, Andrea or Nicolo Amati, or the Guarneri family—or an early Broadwood piano, a Ruckers harpsichord, or a Gottfried Silbermann organ—is acknowledged by experts to be a great instrument. Even if such an instrument is in disrepair, the potential for quality lives in its very being.

Critical ability resides as innate talent in some people just as musical talent is given to others. Those who follow their inclinations to develop whatever talents they possess by becoming voicers may also be motivated by a consuming preoccupation with the nature of sounds that are present in our environment. To that needs to be added a talent for and a devotion to formal music as well as sufficient mechanical aptitude to learn how to handle tools competently.

To practice his craft, a good voicer is not even required to like the sounds produced by pipes. The fact of the matter is that most pipes do not sound musically pleasing. This is not necessarily the fault of the voicer, who may merely be following someone else's prescriptions. But it explains why most organs are not great—indeed, they are not even good—just as the overwhelming majority of other musical instruments are also mediocre.

There are identifiable characteristics that great organs have in common, many of which can be attributed to the voicing. Some of these are common winding of all pipes, direct mechanical key action or its equivalent, suitable wind pressure, encasement, proper placement, a workable specification, and fine craftsmanship. Good results are not hard to achieve in the process of voicing if the organ meets these standards, but the voicer must know what these standards are and how to exploit them as well as how to overcome the difficulties imposed on the task of voicing by organs that fall short of the ideal. The voicer must be able to transcend his own taste if he is working for someone else; he must be as familiar with the standards of his employer as he is with his own. The diversity of taste and style enrich organ building. It is difficult to find an eclectic organ that achieves what is claimed for it; the best organs are faithful to their types only if they are not compromised in the search for universality. The aim of the organ builder should not be to produce an instrument that can "do everything" from pre-Bach to Romantic to avant-garde.

A Note on the Dom Bédos Illustrations. The engravings which illustrate the present book include a large number chosen from those originally published by Dom François Bédos de Celles (1709–79) in Volume IV of *L'art du facteur d'orgues*, a work published between 1766 and 1778. Dom Bédos' plates in most cases serve better than any other illustrations that I could provide to show the details which need to be shown in the present book. His engravings are indeed among the most beautiful and detailed illustrations of organ building and related arts that have ever been produced.

Aside from his book, the organ building of Dom Bédos, a Benedictine monk as well as an organ builder, is represented by what is perhaps his last remaining instrument, an organ at Bordeaux Cathedral. (This instrument was recently restored by Pascal Quioran of Carpentras.) I have chosen specific illustrations by this eighteenth-century master for reproduction in the present book to help explain more clearly the various technical aspects of pipes, tools, and voicing that are discussed in the following chapters.

Of Dom Bédos' 187 plates, the first seventy-five or so exhibit the nature and technique of organ building in eighteenth-century France. The series begins with diagrams that explain simple mechanics with wonderful clarity; thereafter, woodworking tools, chest construction, key and pedal board actions, pipes of all sorts, and scaling diagrams of pipes for a complete organ are shown. The remainder of the drawings, though more of historical or antiquarian than of practical interest today, illustrate several small cabinet organs, two table organs, a forte-piano, a hurdy-gurdy, and the complete pattern required to make the player drum for the hurdy-gurdy so that it plays a little tune.

These illustrations are genuinely encyclopedic in their scope. They form more than merely a mechanical treatise, for they are capable of evoking in the reader a strong flavor of the workplace of an artisan in pre-revolutionary Paris.

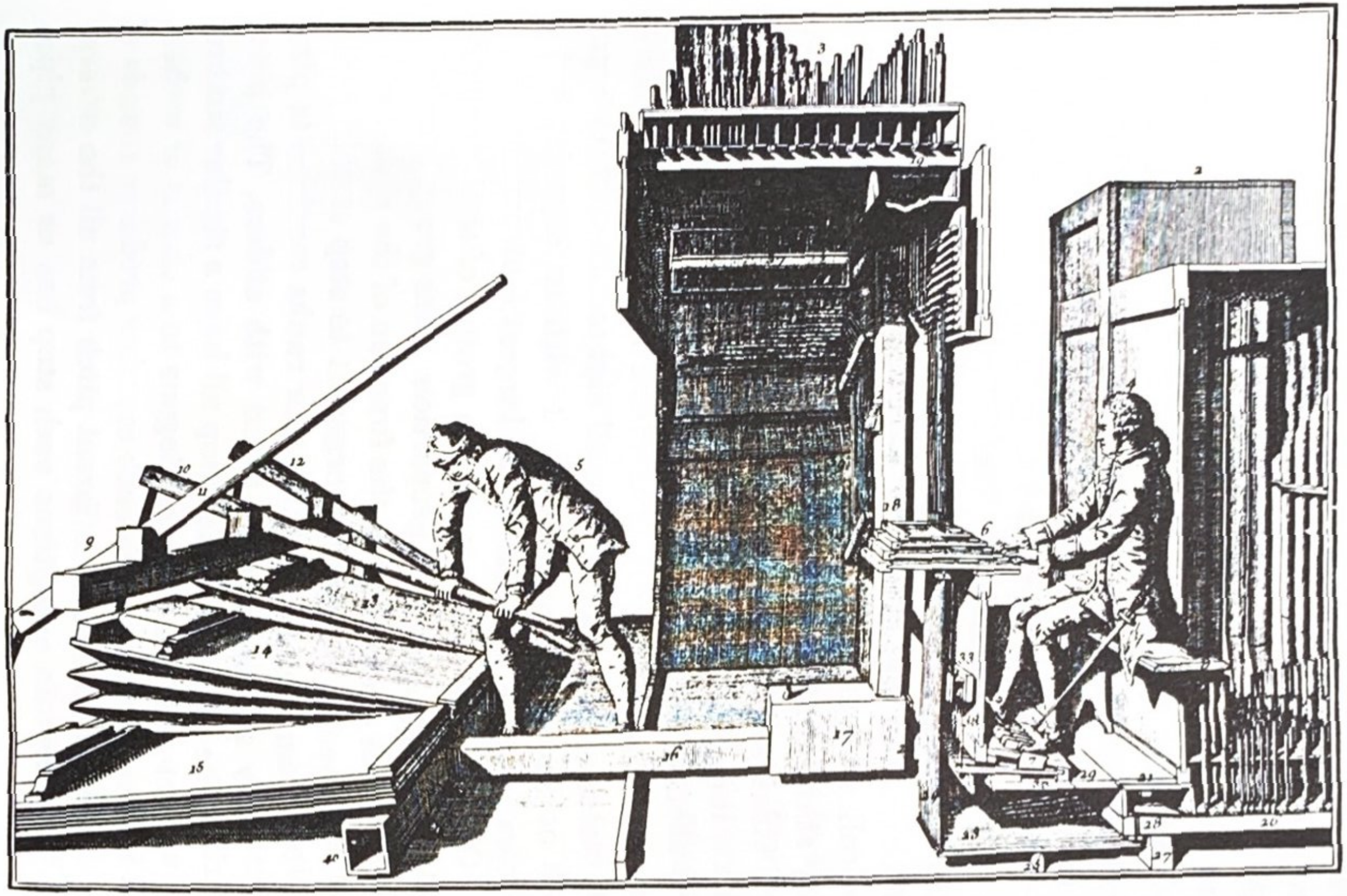
1

Description of Pipes

All musical instruments are made up of two essential parts: (1) a mechanical device that vibrates to produce a musical pitch and (2) a resonator or sounding board to amplify the basic tone and to give it a deliberately controlled musical character. The organ is a collection of musical instruments, each pipe of which thus incorporates a motor and an amplifier. The sounds of the individual pipes are collected and amplified by the windchest upon which they stand and by the case which encloses the back, top, and sides of the pipe area. The whole structure of the organ, including the floor upon which it stands, becomes a soundboard. Hence the entire immediate environment of the organ becomes part of the instrument. This is true in the instance not only of a small eighteenth-century organ such as the one shown in fig. 1 with an organist and a bellows pumper, but also of the largest instruments.

Organ pipes are arranged in groups of similar shapes that differ in length and proportion. Each group is called a *stop*—a term derived from the function of the slider, which was invented to permit the organist to stop certain ranks of pipes from sounding while other ranks continue to play. Eventually all ranks were fitted with sliders. The pipes which make up a particular stop all have a similar timbre. A single stop is therefore analogous to a chorus of orchestral instruments of which each member produces sounds of the same timbre but of different pitch from all the others.

With certain exceptions each stop has as many pipes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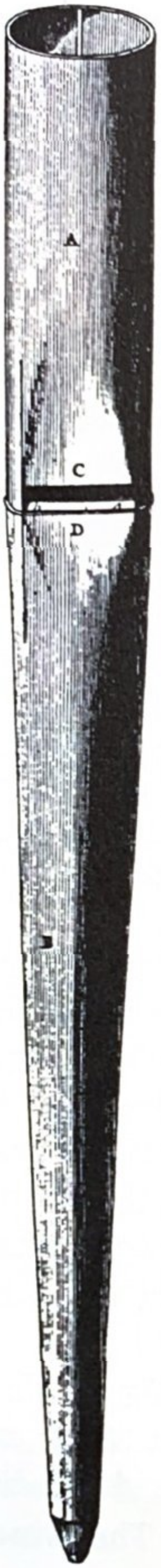
1. A four-manual organ of the eighteenth century.

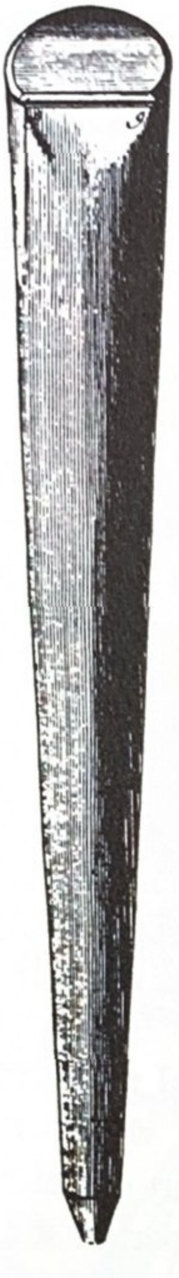
under its control as there are keys on the keyboard from which it is played. When lined up in straight rows, each pipe in the stop is seen to be of a different length, with the largest pipe, as one would expect, sounding the lowest note and the smallest pipe sounding the highest note. Each pipe is of the correct size to contain the exact mass of air that when made to vibrate will produce its intended pitch.

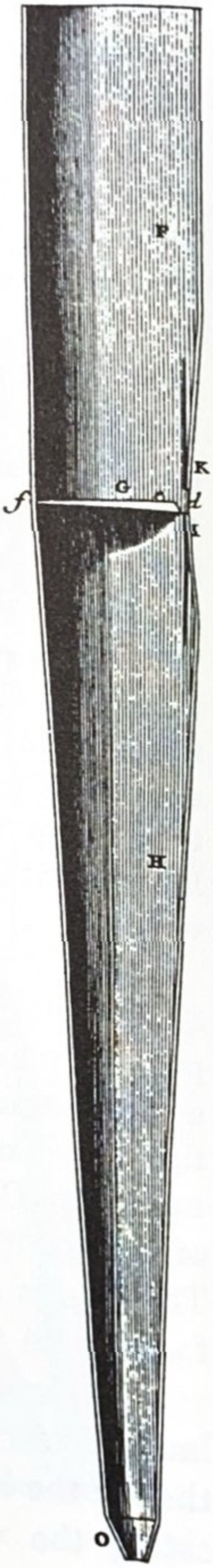
The conventional manner of describing the pitch of pipes depends on terms derived from their length. As in any wind instrument, a pipe open at one end sounding c′ as its fundamental note will be about two feet long. The organ keyboard evolved so that the lowest note in most instruments is CC. From this relationship, the whole system descriptive of pipe pitches is derived. Thus the foundation stops—that is, those of basic character—are of eight-foot pitch since a pipe that sounds CC is roughly eight feet long. From this it follows that pipe lengths decrease by one-half for each octave that is traversed from the bottom to the top of the keyboard. All pipes follow these rules of length with regard to their pitch though their timbre will vary.

Fig. 2 shows a typical principal pipe of 2′ pitch. In fig. 3, the foot and languid, without the body, are shown in perspective. The flue is an opening between the front edge of the languid, which is seen as a dark line between *g*...*g*. In fig. 2 the mouth is the rectangular opening between the upper lip (*C*) and the lower lip (*D*). This distance, the height of the mouth, is also referred to as the cut-up of the pipe. The flue is seen again between *a*...*b* in this view. *B* is the foot, and *A* the body of the pipe.

The same pipe is seen in cross section in fig. 4. The languid (*G*) separates the cavity within the foot (*H*) from that of the body (*F*). The mouth is at *d* with *K* and *L* indicating the upper and lower lips, respectively. The wind







2. Left: Principal pipe: front view of mouth.

3. Above: Principal pipe with the body removed.

4. Right: Principal pipe: cutaway side view.

enters through the hole in the toe at *O*, escaping through the flue as the pipe speaks. Some pipes have ears, which are pieces of metal soldered to the sides of the mouth. Typical examples of ears are seen below on the mouths of the chimney flute and bourdon pipes in figs. 21 and 22.

Pipes that are spoken of as open are open only at one end, the upper one. The lower end is closed off by the languid. Air moving out of the foot through the flue is formed into a windsheet that is directed across the mouth. When the windsheet reaches the upper edge of the mouth, it grazes the upper lip. The friction of the lip generates eddy currents that whip back and forth, causing the windsheet to vibrate like a reed of air. This vibrating motion is transmitted to the air inside the body which resonates sympathetically with the air reed. The mass of the air enclosed by the body determines the frequency of the vibration, which is the musical pitch or note of the pipe. The body resonates in harmony with the air within it—air which imparts a characteristic formant or set of overtones to the composite sound. The precise character of the formant depends on the elasticity of the material of which the pipe is made. The resonance of the air column and the associated resonant components will continue to be audible as long as the air continues to flow across the mouth. Thus the pipe is said to speak.

While most classes of pipes are open, some are closed at their upper end. While having the upper end of the pipe closed does not affect the movement of air across the mouth, it does radically alter the overtone structure of the timbre. A pipe that is fully open on both ends contains within it one full wave length of its vibrations. The sine wave of the fundamental pitch makes one complete excursion through its range of mathematical values, which are the same at both ends of the pipe. The conventional open organ pipe that is closed at one end is only long enough to contain one-half of a complete wave length, and the stopped pipe contains but one-quarter of a wave. The fully open pipe has three nodes: one at either end and one in the center; one quarter of the way along the pipe from either end are the two antinodes. The half-open pipe is not closed by the languid but only appears to be. The mouth acts as an open end. The languid seems to discard half of the wave form so that only two nodes and one antinode appear. The wave form seems to be reflected or folded back along itself. In closed pipes the stopper, located at the antinode, seems to reflect the wave back upon itself a second time so that its two node points overlay one another at the mouth.

It is the half-open pipe, conventionally referred to as open, that conforms to the nomenclature for pipe length. A stopped pipe is only half as long as its pitch length. Thus the open diapason or principal of eight-foot pitch has as its longest pipe a cylinder of metal, closed off at the base and open at its top, that is about eight feet long from its base to its top.

By contrast a stopped diapason or gedackt of the same pitch has a plug in its top end and is only half as long as the open pipe that sounds the same pitch. Otherwise it is similarly shaped.

Organ pipes generate a timbre that is analogous to open vowel tones of the human voice though it is not actually imitative of vocal sound. The smaller the scale of the pipe, the more nasal and edgy the timbre becomes, and the larger the scale the bolder, more powerful, even hooty the tone.

The timbre of open pipes is different from that of stopped ones. Open pipes develop a tone composed of every partial tone in the series beginning with its fundamental pitch and continuing to the highest one of which it is capable of developing. Stopped pipes generate only odd-numbered partial tones. Open pipes generate a sound similar to a schwa or neutral sung *ah* while stopped pipes produce tones that are basically like the sung *uh* or *oo*. Depending on the scale, the tone may be light or heavy. Cylindrical open pipes of moderate scale form the most important body of pipes, the principals or diapasons. The timbre is not imitative of any orchestral instrument but is analogous to the sound of a string ensemble with light woodwinds and horn. Neither are stopped pipes deliberately imitative, although their timbre is considerably more flute-like—that is, cooler and lighter than that of open pipes.

Hybrid or transitional shapes between open and stopped pipes take on the character of both parent groups in proportion to the extent that they replicate the one or the other of the two possible groups. Pipes of this class are not given prominence in the ensemble of the instrument since their timbre is generally lighter than that of open cylindrical pipes—and are often husky and frequently duller in character than the fully stopped ones. Fully open pipes characteristically produce a bright, crisp timbre, possessing a certain majesty of tone if deeper pitches are well represented. Stopped pipes generate bland supportive tone which is extremely prompt of speech and which blends well with more colorful timbres.

The basic neutral sounds of both types of pipes are varied by a number of means. The timbre of open pipes can be shaded toward *uh* or *aw* by increasing the scale (see Chapter 2, below). Similarly by decreasing the scale the timbre is shaded toward *i* (as in *sit*) or *ee* accompanied by the introduction of a distinctly nasal quality.

Stopped pipes are similarly affected so that their basic neutral tone is made duller by increasing the scale or brighter and even somewhat pungent by decreasing the scale. Stopped pipes of extremely large scale are capable of producing powerful tones that are nearly pure sine waves.

Tapering the walls introduces slight albeit distinct alterations to the basic timbre of both open and stopped pipes. Open pipes that are tapered outward, being larger at the top than at the bottom, become increasingly nasal in timbre without the basic vowel tone otherwise being altered. Reversing the taper by making the top smaller than the bottom reverses this trend, and the timbre becomes smoother and somewhat flute-like, again without altering the basic vowel pattern. Such tapered pipes tend to be grouped into three categories, each of which is described as generating a timbre that combines the characteristics of two types of sound—e.g., flute and string, flute and principal, or string and principal. Collectively their timbre is not as bright as basic or smaller scaled pipes would ordinarily be, and the tone tends to be somewhat unstable, a characteristic which is evidenced by a slight and somewhat irregular tremor.

Open wood pipes of relatively small scale are occasionally made with a slight bulge in the center so that the cross section at that location in the pipe is somewhat larger than at either end. This aids in the stability and promptness of speech in such pipes, which generally have the timbre of a slightly gritty-sounding principal, somewhat string-like, but less nasal than if the pipe walls were parallel.

Cylindrical stopped pipes may be made partially open, the effect of which is to introduce a few even-numbered partial tones. This is done by piercing the upper end of the pipe with a hole that is less than the diameter of the pipe body. While such a shape may be found useful, there is usually a cylinder or chimney rising above the hole and open at the top. The size varies according to a predetermined formula, with the length not exceeding that of the pipe body. The smaller the hole and the shorter the chimney the less the timbre is altered from that of a basic stopped pipe.

A variant on the chimney involves a tapered upper body set over a cylindrical base. The upper taper may be up to one-half the total length of the body, and the top is normally open and is half the diameter of the base or less.

Organs of the Romantic era may contain many stops frankly imitative of distinctive orchestral solo timbres. Such stops employ unusual pipe shapes to achieve the desired tone color. A highly specialized variation of timbre can be introduced into cylindrical pipes of otherwise normal construction by drilling a small hole just below the antinode. This alters the internal wave pattern to that of an open cylinder and causes the pitch to sound one octave higher than it would without the hole. For a stopped pipe the hole must be somewhat below one-third of the way between one end and the other, and the pitch will treble, not double, sounding the twelfth above the fundamental. In both classes of pipes there is a noticeable chirping noise imposed on the attack of the note as it generates first its fundamental pitch, after which the pitch leaps to the octave, where it stabilizes.

Other pipe shapes are possible, and there are probably examples to be found or that have been described of virtually any shape that can be imagined. Any rigid container can be fitted with a mouth and made to speak, but the shapes described in the preceding paragraphs include all those shapes of flue pipes which generate timbres that by common agreement are considered musically useful.

The material of which pipes are made will determine some portion of the timbre produced. With any given material the thickness and other characteristics may be varied to produce further alterations in tone. The earliest pipes were probably made of hollow reeds or of slabs of wood glued together. Soft metal began to be used long before modern times—chiefly tin, lead, or alloys of these two metals. Copper and silver have also been used but not in quantity. Pipes made from any rigid material can be made to speak, but only wood and the metals named above are used today for making pipes of fine musical quality. In recent years zinc has been used for large pipes, but in the judgment of most experts their tone is markedly inferior to that of tin, lead, or alloy pipes.

Mahogany, pine, spruce, maple, and oak seem to be the favorite choices for wood pipes. Any wood made up into a pipe that rings with a musical note when struck will be satisfactory. Oak has been the most common European wood for organ pipes and windchests for many centuries. The timbre of wood pipes is somewhat more subdued and seems to have more body than that of similar metal pipes, whatever the alloy. Soft metal is easier to work than most woods and is more stable in the face of changing relative humidity. The tuning of pipes made of metal is far more stable than that of wood pipes, and this probably accounts for its more prevalent use.

Pipes have the task of containing columns of air. Everything done in voicing influences the nature of what happens when the air column vibrates to produce the tone. The wind column moving into the foot from the chest must be like the column of air of a trained singer: flexible rather than unyielding, free from an explosive attack, and not turbulent. No feature of the pipe may degrade the wind flow. No external condition may disturb the windsheet. These factors enable the windsheet to generate steady speech.

All parts of the pipe must be flawless, especially those which affect the timbre of the pipe. The tone from a single pipe should be as clear and musically pleasing to the ear as a single note played on any other fine instrument. Each pipe of a stop must sound similar to all the others. The change of timbre from one note to the next must be so gradual as to be imperceptible when notes are played in order. The attack of each pipe must be prompt so that the combined pipes of any registration speak in the same clear and simultaneous fashion on the downbeat as do the separate instruments of a good orchestra or as do the voices of a good choral group. The aggregate tones must be in perfect musical balance from stop to stop and division to division—a balance that must be insisted upon even though the organist may register improperly and play the instrument badly. There must be no element of the timbre that detracts from the music being played. In the same way, the release of the speech of all pipes must be as natural as the stopping of the sung, blown, or bowed notes of other instruments.

In organs of average size, the loudness of all of the pipes should be within the range of loudness of all other musical instruments. If not, the organ cannot be used with other instruments or with voices. To fail in this regard defeats the present purpose of the organ's existence in the musical culture of Western civilization: to accompany and support human voices. If it does that task well it will also fulfil its other assigned tasks: to accompany other instruments and to enable organists to play the solo literature.

Used in any kind of ensemble, the organ must sound as an equal partner with the other players. There is no excuse for lack of presence, clarity, or tonal focus. All musical criteria apply equally to the organ and to all other instruments. Most of these elements are in the hands of the voicer.

2

The Scaling of Organ Pipes

The scaling of organ pipes is a complex affair. The general theory of vibrating bodies has been thoroughly explored, beginning with Hermann Helmholtz, and most organ voicers are familiar with his book *Die Lehre von den Tonempfindungen als physiologische Grundlage für die Theorie der Musik* (Brunswick, 1863; translated under the title *On the Sensations of Tone*). Even though Helmholtz has considerable to say about the theory of pipe speech, the matter is far from completely understood today, and only the most rudimentary aspects of the subject have been reduced to formulas. The existence of the air reed, for example, was deduced by Helmholtz, but its mathematical definition remains elusive.

The more pragmatic aspects of scaling do not require an understanding of the theory behind the techniques, however, but only a familiarity with the empirical aspects of the art. As with any other art, theory generally lags behind practice. An art form is developed and perfected by its practitioners who have an intuitive understanding of what they are doing; thereafter others codify and explain what has been done by the artist. The artist is not concerned with following the rules that others devise to explain their art because the artist's judgments about his art derive from his own internal and subjective rules. Herein lies much of the difficulty of explaining what essentially is an artistic function—that is, scaling organ pipes.

There are rules to be followed, to be sure, but they are chiefly the organized expression of empirical determinations made by practical voicers. These rules make up part of the theory certainly, but not all of it and perhaps additionally with imperfect understanding. Since the present book is not intended to be a theoretical treatise, the discussion of scaling here should be understood only as a practical guide to the subject.

Scale is a collective term that describes those major measurements of the pipes in an organ which affect its timbre. The pitch of a stop, given in feet, is one of the components of the scale. The scale number arbitrarily or directly indicates the diameter of the lowest note of the stop. It is expressed in inches, millimeters, or any number that refers to a specific formula from which the diameter may be determined.

The halving ratio indicates the correct progression of pipe diameters from bass to treble and is given as the ordinal number of that pipe in which all dimensions are one-half those of the lowest pipe. This number is then set as the reciprocal value of that power of two by which each successive decreasing diameter is multiplied in order to find the diameter of the next note. In American and English nomenclature the count begins on the first note, giving a number which is one higher than the root to be taken, but in Continental nomenclature the first note is not counted. Elsewhere in this book the halving ratio will be described in the American system, meaning that a seventeen ratio is calculated from the sixteenth root of two.

Other major dimensions are pipe length and mouth width. Scale, thus defined, describes pipes sufficiently for them to be made accurately. The mouth width is expressed as a fraction of the circumference of the pipe body and varies between 2/7 and 1/9. All values between these numbers are possible, but commonly only small fractions are used to designate the mouth. There must be a distinction made between the general fraction given as a segment of a circumference and the actual dimension that is built into the pipe. If the mouth is formed by flattening the body there is no practical difference whether the distance around the outside of the pipe wall at the mouth is called the *circumference* or the *perimeter*. The difference is semantic. If the mouth parts are cut from flat pieces which are soldered into a pipe body that has been cut out to receive them, the mouth width is part of neither the circumference nor the perimeter but is the chord taken across the circle of the diameter between those points indicated by the fractional number. It is a straight line and therefore is shorter than the circumferential line, making the mouth of such a pipe slightly narrower than the mouth of a pipe formed by flattening the circumference of similar dimensions.

Any set of measurements may vary in linear progression or in any other proportion. Most stops may be described by simple linear formulas. When the departures from linear ratios are used they are generally very slight. Thus the scale of a typical foundation principal begins with its name and pitch which together tell the organist something about its tone, and this is followed by those particulars which are beyond those engraved on the drawstop—e.g., diameter 150 millimeters, halving ratio seventeen, two-ninths mouth width. In a stop so described, the second octave E is half the diameter of CC, the third octave g#″ is half the diameter of E, etc., and the ratio 2/9 says that the width of the mouth is two-ninths the circumference of the body of each pipe. If the diameter of CC is 150 millimeters, then by the halving ratio formula that of E is 75 millimeters and of g#″ 37.5 millimeters. The circumference of CC is 471 millimeters, and the mouth is two-ninths of that—i.e., 104 millimeters. All other pipes follow the same ratios. Together these numbers, the scale and the halving ratio, describe the diameters of all pipes in a stop, but their length is controlled by the natural relationship of the wave length to the pitch of the notes (see above, pp. 9–10). It is impractical to attempt the precise determination of pipe length because of the number of variable factors affecting pitch. Only if every dimension of the pipes from one note to the next varied in a theoretically perfect relationship would this be possible.

In the nineteenth century, Johann Gottlob Töpfer, a German mathematician, published a shorthand method to describe pipe scales in a way that would easily accommodate any commonly used scale pattern (see *Die Theorie und Praxis des Orgelbaues*, 2nd ed. [Weimar, 1888]). He took the measurements of as many organ stops as he could and by statistical means derived what he then called *Normalmensur*, or normal measure. He calculated that the average diameter of CC of the eight-foot principal on the main division of the average organ in the average church was 155.5 mm. (in rough figures, approximately six inches) and that the average halving ratio was the seventeenth. From these data he created the system now in general use by organ builders to designate scales, using the abbreviations NM (for *Normalmensur*), NM + 2, NM – 3, etc.—a system which expresses these basic dimensions of pipes in a convenient shorthand form.

Modern systems of arbitrary scale numbers are based on Töpfer's *Normalmensur*. One system in use is based on the designation of a pipe one meter in diameter as being Scale 1. If this pipe were CC (not likely, of course, but it will be useful here to pretend that it is), CC# would be called Scale 2 and would take its diameter from the size it would have in Töpfer's *Normalmensur* series. Continuing up the scale, Töpfer's NM standard pipe is nearest to Scale 44 in this system—i.e., 155.23 mm.

No scaling system should be taken as anything more than a description of dimensions after the fact. There is no basic artistic rule to be inferred from them, for they only describe to another person what an artist has already done. The arithmetical tables of a scale enable the pipe maker to give the voicer what is necessary to put into a particular instrument, but unless a scale is related to the art of the organ builder it will stand little chance of being musical. Variable scales are used for most stops in an organ. If the scales of an existing organ that is voiced to fit its environment are analyzed, they usually show that its builder has taken the acoustic nature of that space into account. The scale patterns vary from being a simple straight line in a manner that compensates for variations in the way certain frequencies behave in the room where the organ is built. Töpfer's *Normalmensur* system simplifies such analysis since, instead of having to draw a mathematically complicated set of lines, the parts of a scale where the pipes should be larger or smaller than the straight NM line are noted either as NM plus x or NM minus x, with x being equal to the number of half-steps larger or smaller than NM at that place in the scale.

Töpfer did not originate an ideal scale. He described a collection of existing scales with an arithmetical designation. The significance of his work is the collation of information into a codified form that enables one to make and describe scales quickly in an easily understandable fashion.

Every characteristic of a pipe has a bearing on its timbre. Each of the primary characteristics discussed above—scale, halving ratio, and mouth width—has a different effect on the nature of the sound. The scale of a stop affects the loudness or power of the sound. A principal stop of large scale will develop enough sound to fill a large room and to support the major chorus of the organ. In the same room a principal of smaller scale will not be able to develop as much power as one of large scale, but its timbre will be brighter. It will not overpower or even compete with the larger stop, but if it is placed correctly in the specification it will augment or contrast with the large scale stop. Such a relationship exists in the members of a well-designed principal chorus. If the pipes of 1′ pitch of a chorus are laid out in a row from large to small, the Principal 8′ should be the largest. Next in order should be the pipe from the Octave 4′, followed by increasingly slender pipes of higher and higher pitches. There is no uniform rule about these relationships from one builder to the next.

If principals of 8′ pitch are located in other divisions of the organ they will be smaller in scale than the principal of the first division. The normal relationship between the fundamental principal and its octave is reversed in the pedal. A 16′ principal would be uncommonly large if it were twelve or more half steps larger than the manual principal, and its timbre would be quite dull. To insure that the bass timbre is incisive and clear, the scale is made equal to or somewhat smaller relative to that of the manual choruses; also, in order to restore the gravity that one expects from full pedal, the octave, which is of 8′ pitch, is made correspondingly larger (usually by a note or two) than the manual 8′ principal.

This kind of relationship is based on the idea of developing a pedal division not of numerous 16′ stops of different power and tone color but of fewer fundamental stops that are augmented with upperwork. Such an approach enables the builder to keep the size of a free-standing encased organ within reasonable bounds.

A principal of ordinary scale will have a mouth width of

1/4 or 2/9. A pipe of principal scale with a mouth smaller than 2/9 is an open flute, not a principal. A principal with a mouth wider than 1/4 generates a powerful and aggressive tone. Such pipes have limited musical use, chiefly in the main chorus of an organ in an extremely large room or in the treble of a powerful reed stop. There is a better way to increase the power of a chorus without resorting to oversize mouths—i.e., doubling the ranks at the unison or the octave pitch. Only if this means fails should 2/7 mouths be used for the chorus pipes.

An 8′ principal with a 2/9 mouth produces a smooth, almost bland tone that in a reverberant room sounds quite rich. The same stop with a 1/4 mouth is brighter, more forceful, less smooth but livelier in effect. Not uncommonly a chorus is developed with an 8′ principal with a 2/9 mouth accompanied by a 4′ octave with a 1/4 mouth. Higher pitched principals in any given chorus may be made with all 1/4 mouths, all 2/9 mouths, or mixed, with unisons at 1/4 and quints or other pitches at 2/9 according to the builder's preference.

Whatever the scale of the 8′ principal of the first division, all the remaining principal ranks of that division should be scaled in relationship to it so that there is some cohesion of the chorus when registered as a plenum.

Very small scale principals cannot be made to develop much power and are found as dulcianas and the like, a class of stop which is seldom used in a chorus. If the loudness of a narrow stop is increased, it must be helped to speak by unnatural voicing aids—e.g., slotting the pipes at the top. If stops of this nature have a narrower mouth than 1/4 they are more successful, and if carefully voiced they yield usable organ string tone.

Open pipes larger than the normal range of principals are usually made with mouths no wider than 2/9 and are cut up to a higher proportion than would be a principal. So treated, they are classed as open flutes. The scale may be quite large as long as the mouth remains small, with 1/9 being a practical limit. While flutes of 8′ pitch with 2/9 or 1/5 are common, the smaller mouths are found mostly in higher pitched stops. The mouths of stopped pipes range between ratios of 1/4 and 1/5 in width. The mouths of wood pipes have similar proportions to metal ones except that they are usually not square; thus they are rarely as wide as 1/4.

The halving ratio of a stop determines how the treble of a stop will sound in relationship to its bass after the organ has been voiced to fit its environment. If the halving ratio is correct, there will be no difficulty in voicing the treble of a stop so that it sounds bright and clear or in making the bass of an 8′ stop to sound firm and secure. In a non-reverberant space an 8′ stop, especially a principal, will need to be of larger scale than NM, and it should halve on a ratio that is larger than the seventeenth. In similar fashion any other deviation from ordinary acoustics may be accommodated by varying the scale—a process which will vary the halving ratio in a non-linear manner, as pointed out above.

The net effect of variable scaling is that the pipes are made larger than usual in diameter in any register of a stop that requires more power, enabling the voicer to increase the power of a note without sacrificing its timbre. The converse is true if less power is called for.

There are practical limits to the extent that a scale can be altered. If carried far enough, the timbre of a principal will inevitably become that of a flute or a string. The principles involved here will explain why organs sound unmusical in unfavorable acoustics in spite of the best efforts of the builder.

The most musically pleasing results are to be obtained if the space is reverberant enough to enhance the sound of any kind of music (but not enough to muddle it), if the space treats all audible frequencies more or less evenly, and if the organ scale patterns are straight lines or smooth curves.

There are other dimensions of a pipe, some of which are specified to the pipe maker and some to the voicer. They are not part of the scale, properly speaking, but each has a part in determining the timbre of the voiced pipe. The composition and thickness of the metal and the nature of the languid must be decided upon before the pipe is made, and the height of the cut-up is set by the voicer in determining the power and color of the stop as it is voiced.

The thickness of the languid is chosen to control its stiffness, which bears a direct relationship to its ability to remain flat without sagging as the pipe ages, and to assist in the control of the direction of the windsheet. The front edge of the languid is planed to a deliberately chosen angle for its effect on the inclination of the windsheet. If this angle is around 60 degrees, and if the languid is relatively thick, the windsheet is drawn to that surface and is pulled inward toward the lip. This means that the languid must be placed relatively high for the pipe to develop its brightest and most stable timbre and that a slight vertical displacement of the languid has a relatively great effect on the displacement angle of the windsheet. The closer this edge approaches a right angle, the more pronounced the effect becomes.

Also, a corresponding increase in “white noise” will be generated by the pipe, and hence approximately 75 degrees is the practical maximum limit. Decreasing the angle below 60 degrees lessens the effect of the languid displacement on the angular displacement of the windsheet, and the windsheet tends to move straight up or slightly away from the lip. The languid must be brought down to redirect the windsheet, but its low position darkens the tone. The voicer has no control over the angle of the languid bevel since this detail is determined before the pipes are made.

The most important dimension fixed by voicing is the height of the upper lip above the flue, the cut-up of the pipe. This dimension determines the distance that the windsheet travels after it leaves the flue until it impinges on the lip to make the note speak. The windsheet itself is the heart of the timbre; without a windsheet, there would be no sound from the pipe at all. For the tone to be easily produced, the windsheet must operate efficiently, and if the lip is the wrong distance from the flue in either direction the windsheet either gets in its own way or gives out before it does its job.

The cut-up height is largely a function of the pitch of the note in any specific organ. It is independent of the width of the mouth of the pipe. If an organ is correctly voiced for the space into which it speaks, all of the flue stops in a particular division will be cut to nearly the same mouth height when compared note for note.

This relationship is usually expressed in a more roundabout way. If the 8′ principal of an organ in a room of moderate size has a mouth width of 1/4, the cut-up ratio might be 1/4. In that same division any stop with a 2/9 mouth will have a 2/7 cut-up, and if the mouth width is 1/5 the cut-up will be 1/3. While each of these mouths are different, all of them will measure about the same between the flue and the upper lip. Only their widths will be different. While this rule is not absolute, it is accurate enough so that if one stop is voiced empirically by setting its cut-ups appropriately to its environment, the cut-ups of all the other stops in that organ that are similarly placed can be expected to measure the same as the corresponding notes of the first one.

Thus a voicer may dispense with the use of proportional dividers altogether except for stops of a markedly different dynamic level than the average. To work without dividers, a chart must be prepared for the lining out of the heights of each note so that the direct measurements are transferred from the chart to the pipes with a pair of compass points. The actual proportions need not even be known, although if measured after the fact they will be seen to follow the rules of the proportional system described above.

The absolute cut-up determines the dynamic level of the pipe and, by extension, of the organ as a whole. It is closely related to the wind pressure in the foot of the pipe. The two values together determine the timbre of the stop within the range of color variation that is possible in the particular type of pipe being voiced. If an organ is voiced for a very small room the wind pressure in the pipe feet must be quite low, between 40 and 45 mm., and the cut-up of a 2/9 mouth principal may be as low as a 1/5 ratio. If so, the timbre will be bright, very gentle, and a bit unstable. If the pressure is raised the note will speak more loudly and will become more unstable. To restore the stability the cut-up must be raised, making the note a bit quieter, a bit duller in timbre, and more stable.

Each time the pressure is raised, there is an increase in loudness and a decrease in stability that must be offset by raising the height of the upper lip. The upper limit of wind pressure before the timbre deteriorates is about 75 mm. If the foot pressure is raised beyond that value to increase the loudness of the note, the windsheet becomes unstable, and the voicing measures necessary to bring it under control limit the number and strength of upper partial tones of the note. This limits its brightness. The pipe begins to sound dull and coarse, losing its musical interest the more it is pushed.

The height of the cut-up should be controlled as carefully as possible, and the upper limit must not be exceeded in the final voicing. It is better to begin with a conservative value which can always be increased than to exceed the maximum limit. Once a pipe is cut beyond its limit it must be re-made.

In Chapter IX of his early twentieth-century treatise on organs, the English architect George Ashdown Audsley illustrates the degree of interest among organ builders and physicists of his time in the exact nature of production of tone by organ pipes (*The Art of Organ-Building* [New York: Dodd, Mead, 1905], pp. 357–96). While his prose style is turgid and verbose, Audsley nevertheless presents a fairly accurate description of the state of knowledge about the operation of flue pipes. Audsley's work must be read with caution, however, since he espouses a particularly one-sided view of organ design which, fortunately, did not prevail. But his curiosity was boundless, and he read widely and quoted voluminiously from other writers of his day.

3

Pipe Making

The first step in creating the music-producing parts of an organ is to make the pipes. The technology of making pipes should necessarily be understood by anyone who aspires to learn how to voice them. A description of pipemaking in this context should thus explain the relationships of the parts of pipes and their functioning—i.e., how their structure enables pipes to speak when wind is blown through them. Fortunately, pipes and the steps in the processes involved in making them are illustrated with great clarity and in considerable detail by Dom Bédos.

Figs. 5–7 show a pipe shop and its equipment. Pipe metal is made up of tin or lead, but more often an alloy of the two metals is used to which traces of copper or antimony have been added for stiffness. The molten metal is poured into a box from which it is released through a gate onto the surface of a casting table, where it cools and hardens. Two different styles of casting tables are shown (figs. 5–6); one has a horizontal slab, the other a tilted one. Other details in Dom Bédos' engravings illustrate their construction. A third style of table, not shown, is made of a stone slab covered with canvas.

After the metal has cooled, it is rolled up for storage and aging. Fig. 7 shows coils of metal behind a worker, who is hammering a new sheet to temper it.

Some builders today plane new sheets of metal to precise thickness on a large drum lathe, although the practice of hammering metal to thickness is still observed

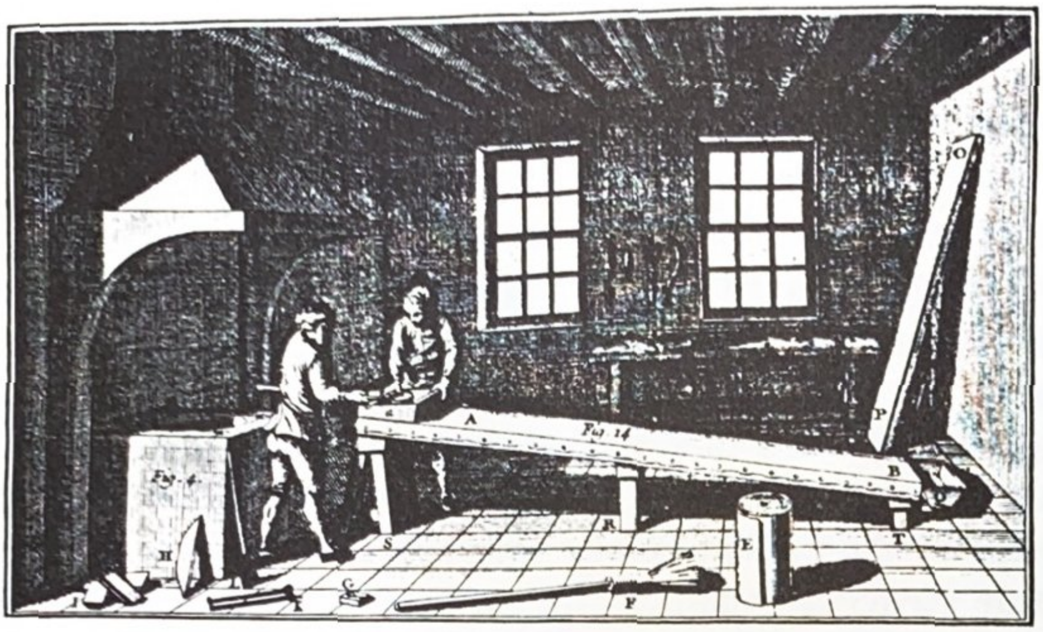

O
P
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Fig. 14
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Fig. 4
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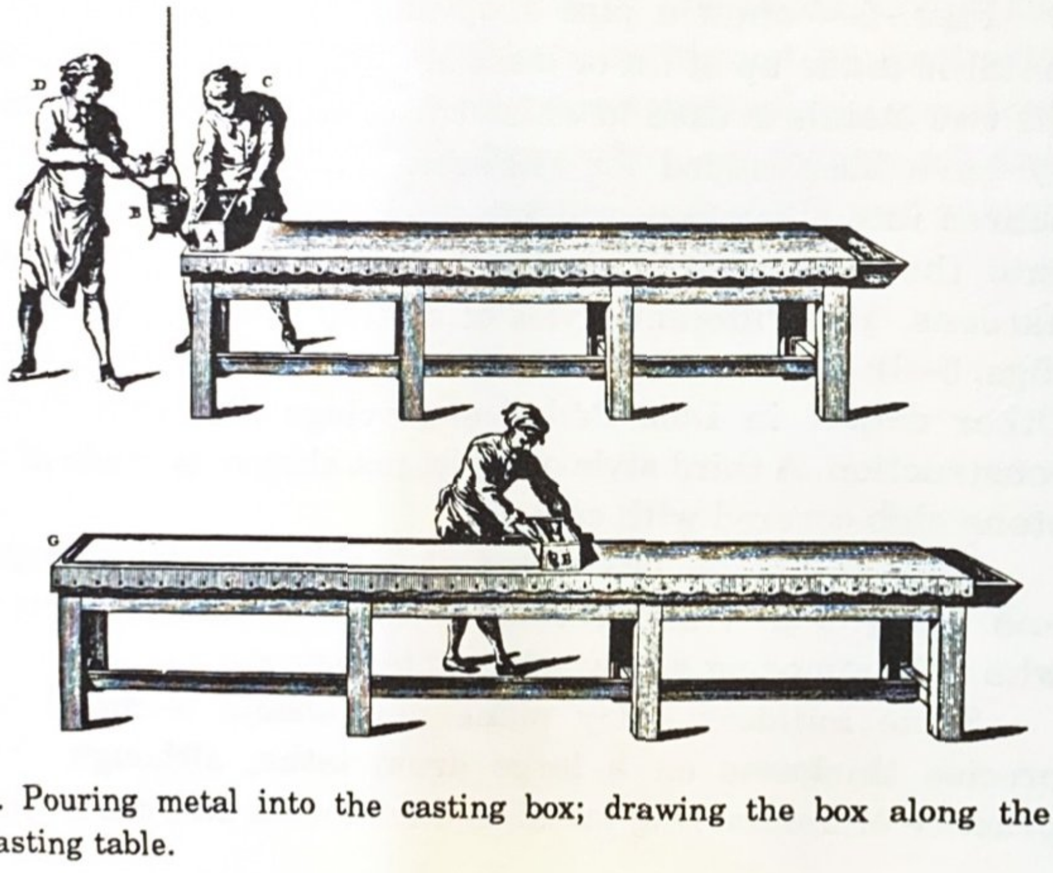
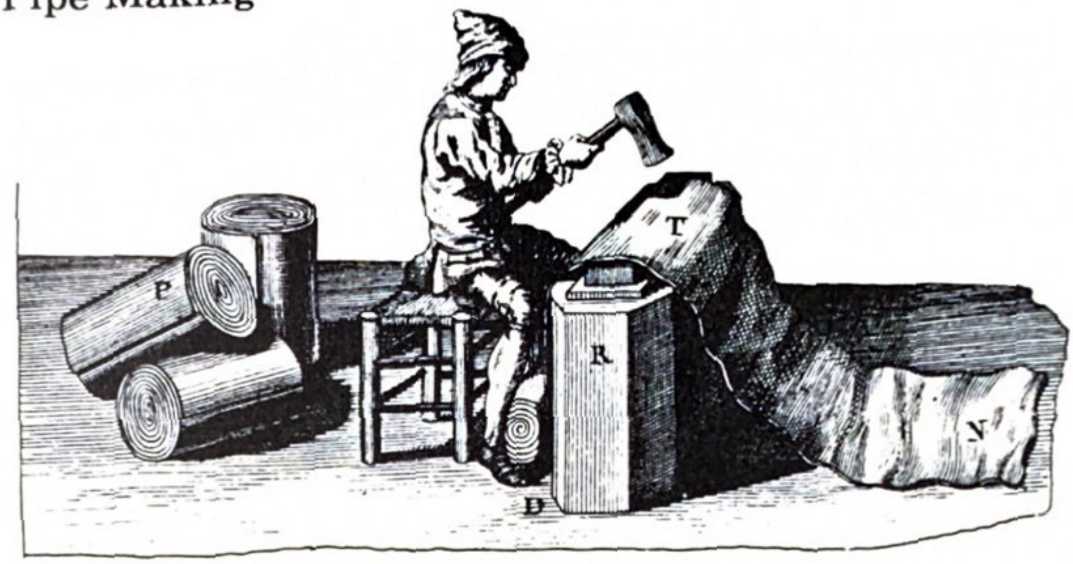
5. Casting room showing furnace and metal being poured on a slanting table.



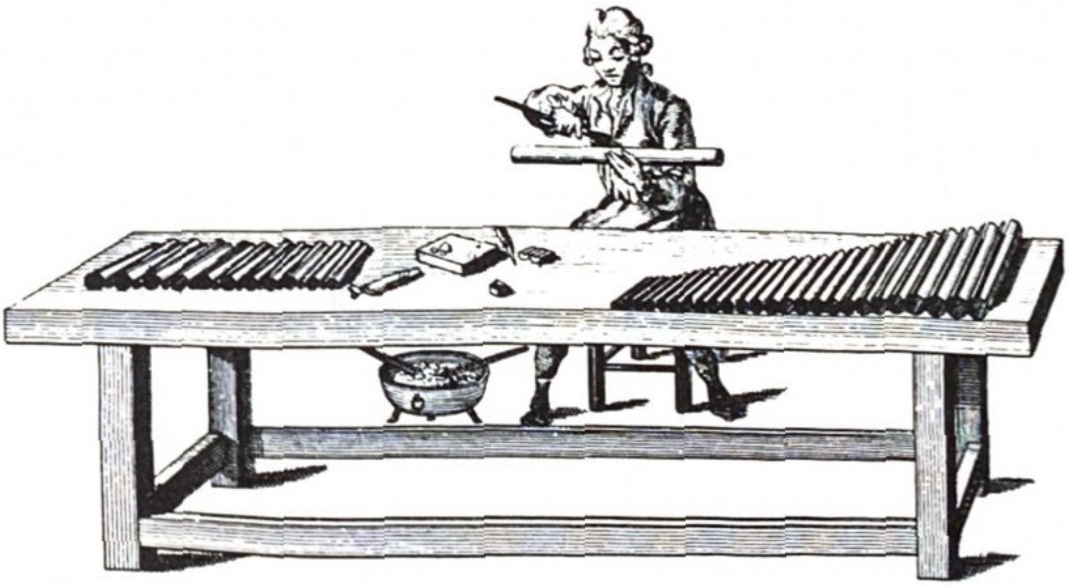
6. Pouring metal into the casting box; drawing the box along the casting table.



7. Coils of pipe metal; pipe maker annealing new metal.

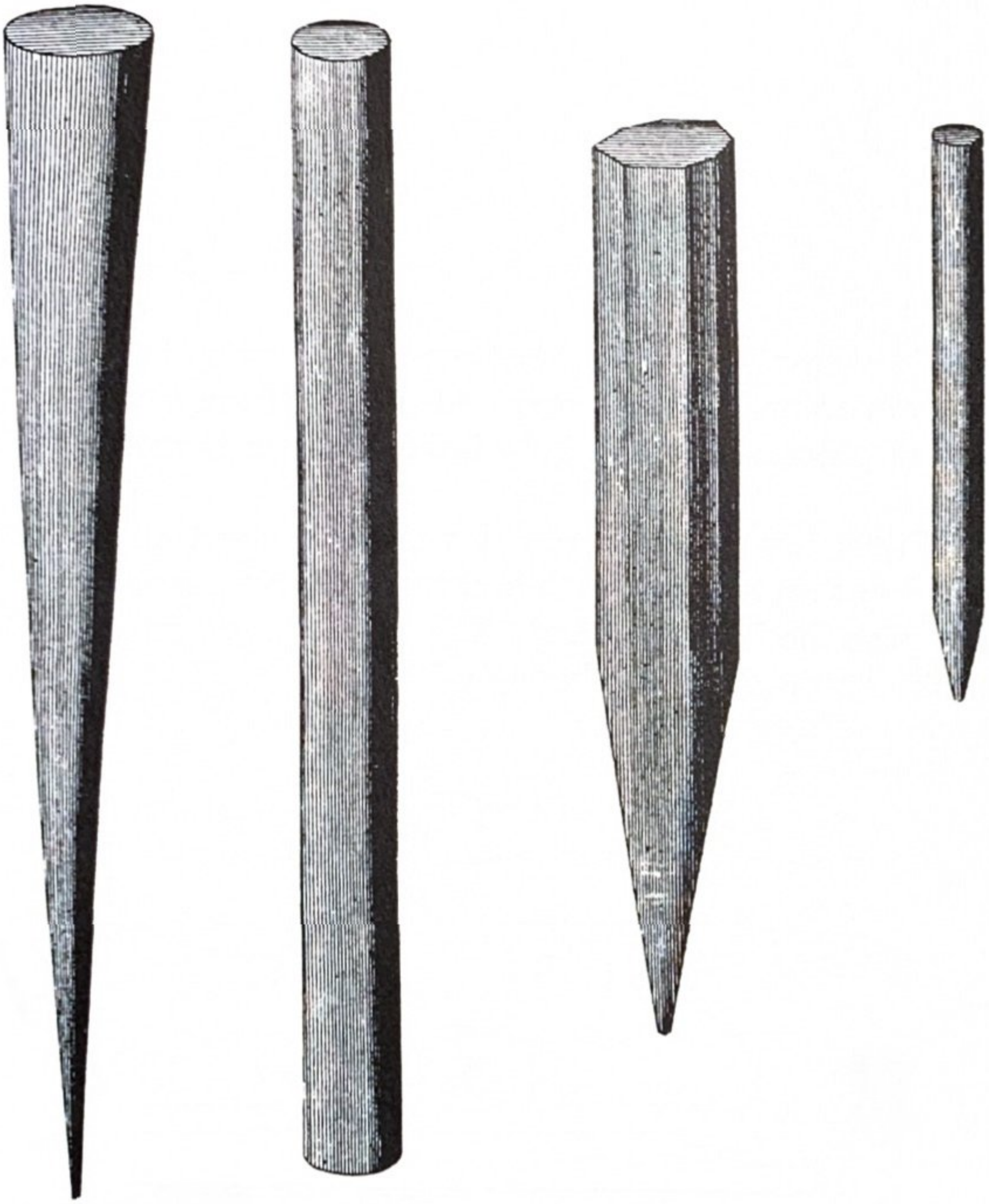
in many smaller shops. Most pipe metal today is baked in an oven to accelerate aging and curing of the metal—necessary processes which help finished pipes to retain their shape.

Pipes are made in complete sets. A sheet of metal is rolled out on a workbench and scribed with the outlines of the pipe bodies and feet. The pieces are cut out and stacked on a workbench, as in fig. 8.

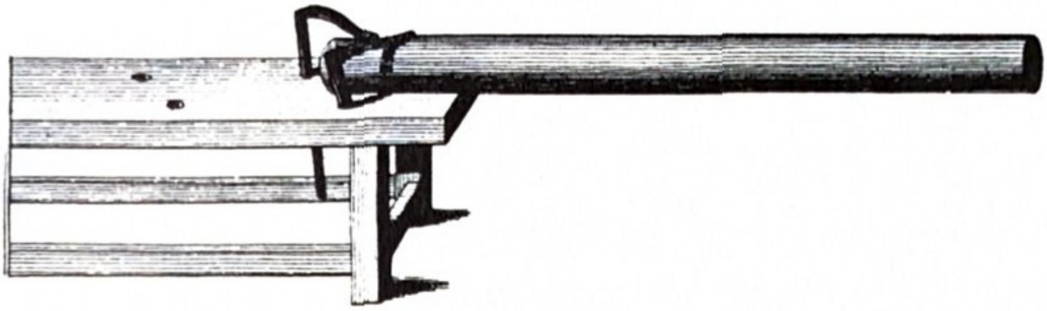


8. Pipe maker soldering a pipe body.

Pipes then are shaped over wooden mandrels of cylindrical or conical shapes such as those illustrated in fig. 9. The metal is wrapped around a mandrel (attached to a workbench as shown in fig. 10) and then beaten into its



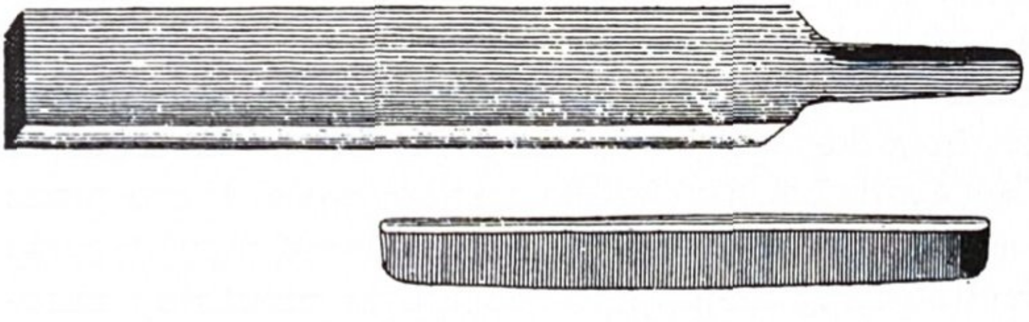
9. Mandrels for shaping pipes. Left to right: tapered mandrel for reed bodies and the feet of flues; cylindrical mandrel for pipe bodies; foot mandrel or mouthing tool; reed boot mandrel.



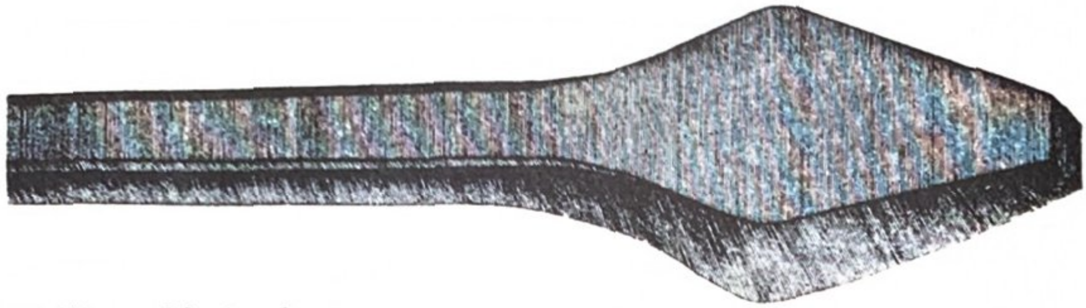
10. Work table and mandrel for forming a pipe body.

proper shape with a pipe beater, of which two sizes are shown in fig. 11. The beaters are boards of *lignum vitae* wood, the edges of which taper smoothly to rounded corners to prevent the soft pipe metal from being indented with the pattern of the beater stick. In shaping the pipe the body sheet is laid on top of the mandrel and pressed down with the hands until it is molded to a cylindrical shape. Then the beater is slapped forcefully against the metal until it conforms to the mandrel. The cylinder of metal is removed from the mandrel, and its edges are joined with solder (see fig. 8). The foot is shaped and soldered similarly, after which the languid is soldered to it.

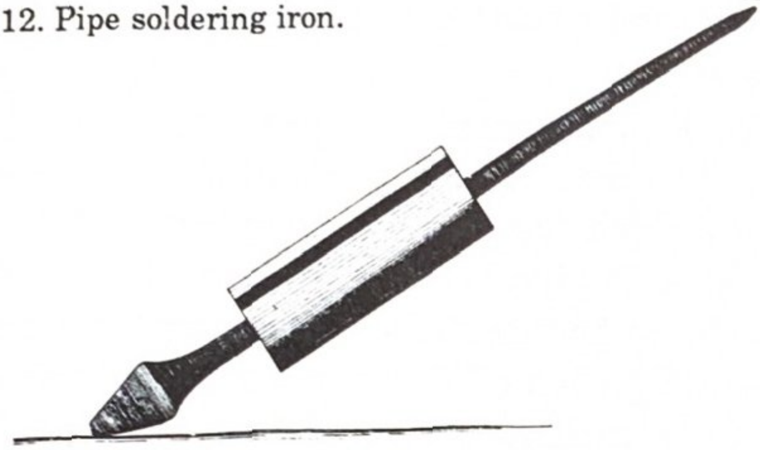
An iron of the special shape used for organ pipes has a blunt nose and looks something like the head of a venomous snake (fig. 12). Dom Bédos also illustrated its handle, which is insulated (fig. 13). Modern irons are similarly made, with most pipe makers still preferring to use the old-fashioned types that are heated over a flame.



11. Beater sticks used to shape pipes against mandrels.



12. Pipe soldering iron.

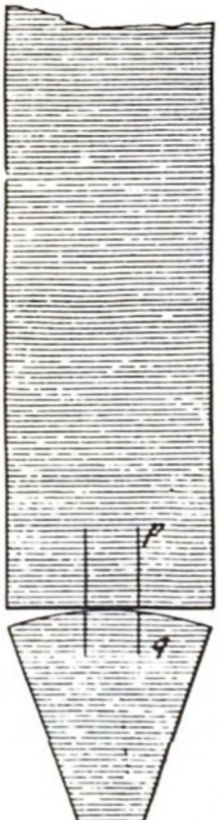


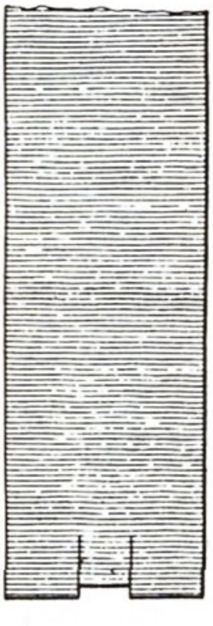
13. Soldering iron with handle, showing how it is used to draw a pipe seam.

The metal for languids is cast in a languid mold in a long strip of which the front edge is planed to the desired angle. The pipe circles are scribed on the languid strip, and they are then cut apart and sorted out with their respective pipes. The flat foot and body look as they are shown in fig. 14, with fig. 15 illustrating a pipe that has had the mouth cut out of it prior to being formed. Typical case pipes are shown in fig. 16 with a bay leaf mouth and in fig. 17 with a rounded or French mouth. More elaborate case pipes, made of several decorative and reinforcing parts, are not uncommon. The ornate pipes in figs. 18 and 19 are from the main façade and a side flat in the organ of Béziers Cathedral. Unlike the smaller pipes, these pipes are made with separately cut and soldered mouth parts instead of being beaten into shape over mouthing mandrels.

The interior pipes shown by Dom Bédos are typical examples of their kind. Illustrated are a principal (fig. 20), bourdon (fig. 21), chimney flute (fig. 22), blockflöte (fig. 23), flûte ouverte (fig. 24), and mixture (fig. 25).

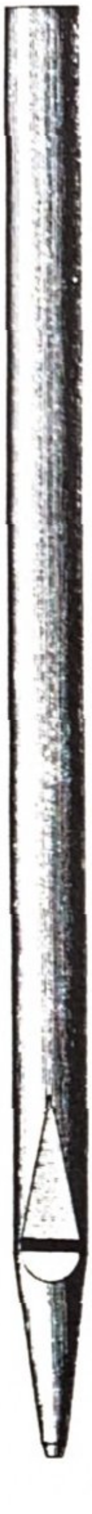
Before being soldered, metal pipes are coated with a paste made from whiting dissolved in glue. This compound, painted on the metal wherever there is to be a solder seam, acts as a heat sink and prevents the unruly spreading of the solder, causing it to round into a neat bead. The compound must be washed off with hot water before the pipe is voiced. If it remains inside the pipe foot it will interfere with the wind flow, and if it flakes away and lodges in the flue the voicing and tuning will be upset.

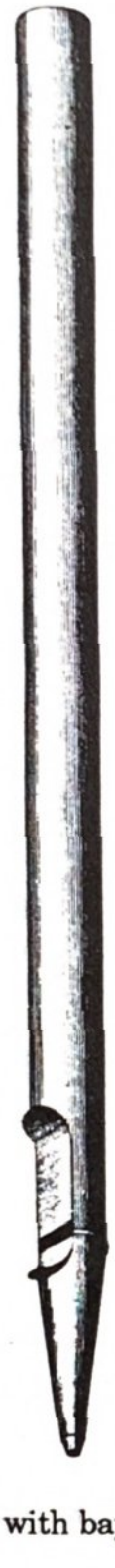


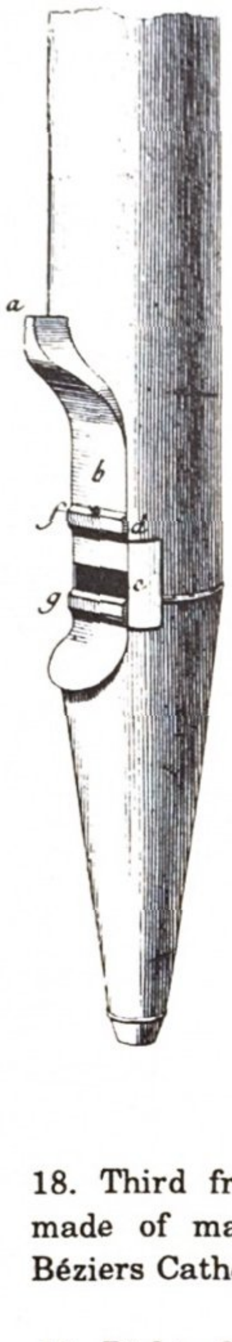


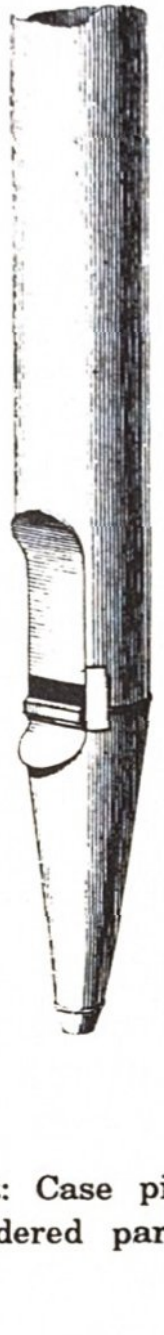
14. Left: Pipe body and foot laid out flat before forming.

15. Right: Pipe body before being formed, with upper lip cut out.







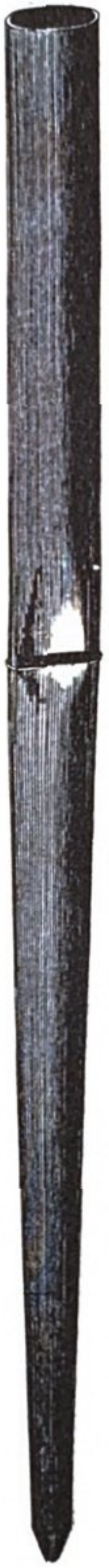


18. Third from left: Case pipe made of many soldered parts. Béziers Cathedral.

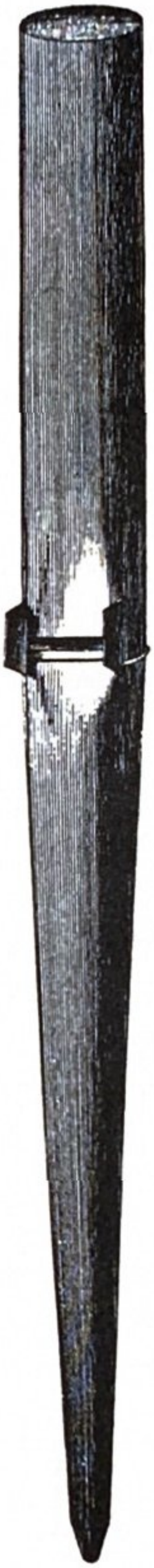
19. Right: Case pipe with reinforced French mouth. Béziers Cathedral.

16. Left: case pipe with bay leaf mouth.

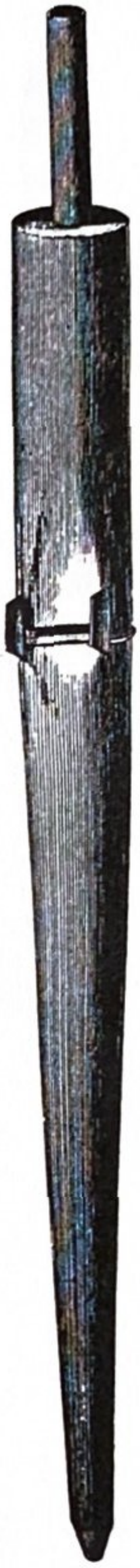
17. Second from left: case pipe with French-style mouth.



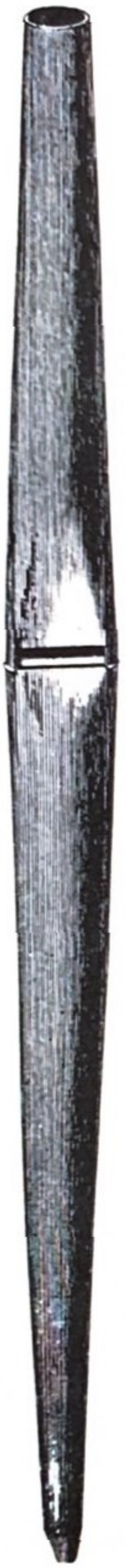
20. Principal: c″.



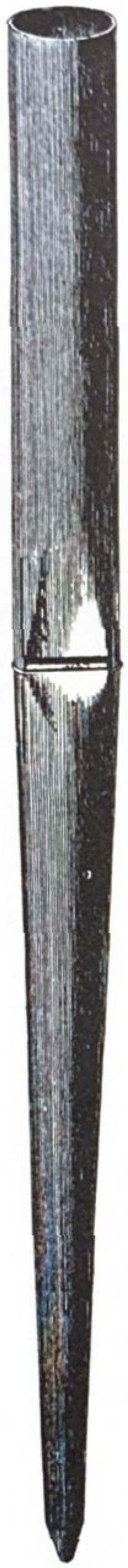
21. Bourdon: c′ .



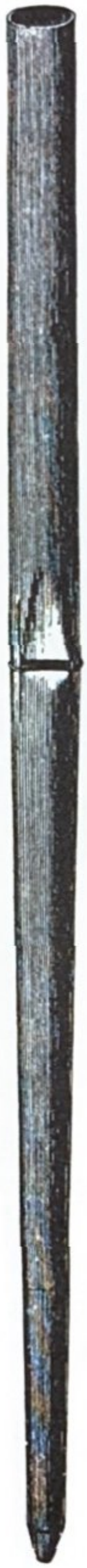
22. Chimney flute: c′ .



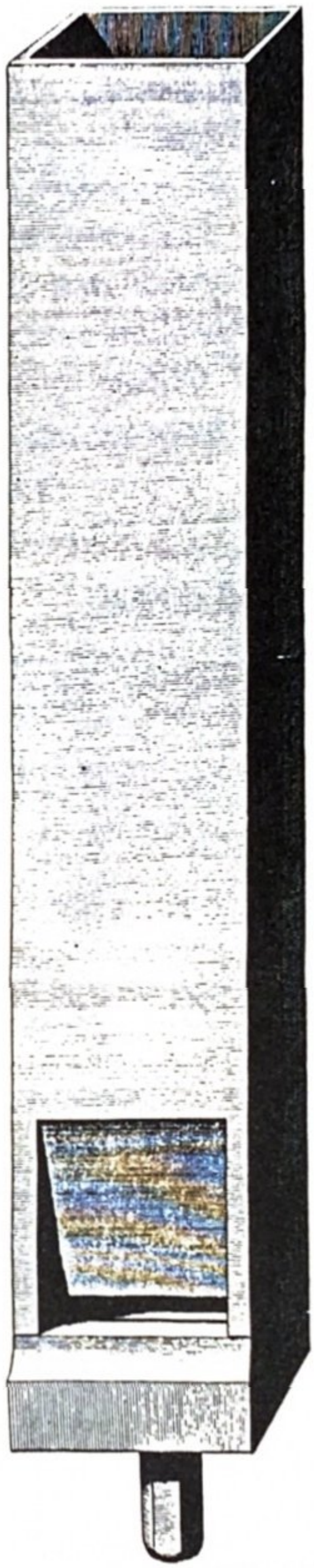
23. Blockflöte: c″.



24. Flûte ouverte: c″.



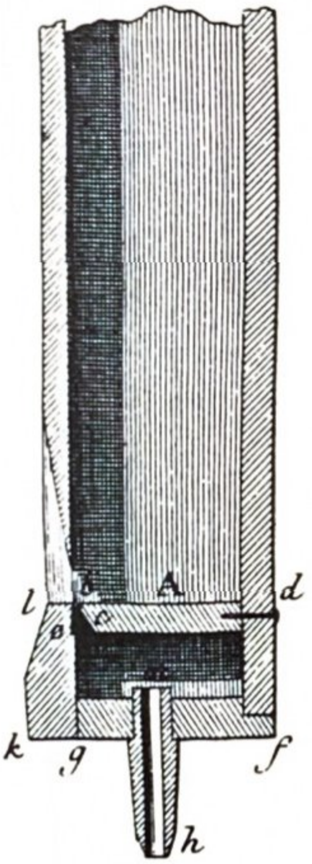
25. Mixture: c″.

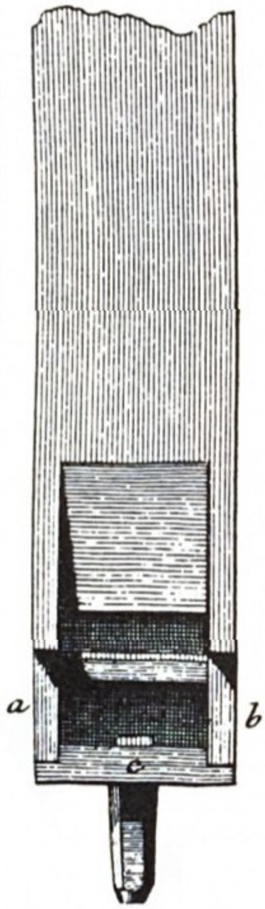


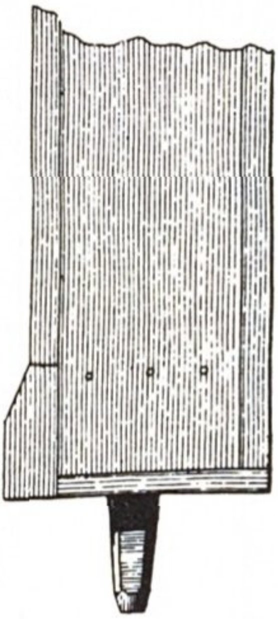
26. Lower section of pedal open pipe.

When the pipes are dry they are laid in the shallow trays in which they are taken to a voicer.

The making of wood pipes is a matter of cabinetry. The pipe maker must know how to match wood types and grains and how to make glue joints that will remain airtight permanently. The shapes are analogous to those of metal pipes. The lower end of an open wood pipe such as a pedal open diapason is seen in fig. 26 and of a stopped pipe in figs. 27–29. The walls of the pipe form both body and foot, made of four planks rabbeted together. Figs. 27–28 show cross sections of a pipe in side and front views. In the front view (fig. 28) the cap is omitted. The languid,



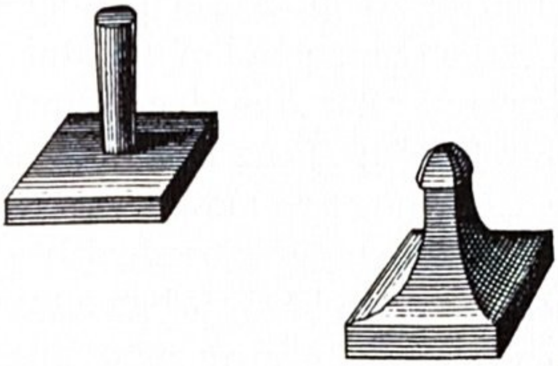




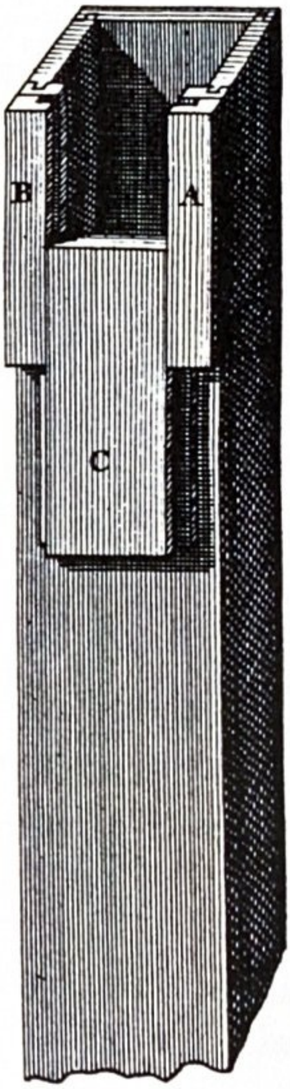
29. Wood pipe, side view.

27. Left: wood pipe, side cutaway view.

28. Center: wood pipe, front view without cap.



30. Two types of stoppers for wood pipes.



31. Top of an open wood pipe with movable slide tuner.

c in fig. 27, is also referred to by English-speaking builders as the block. Unlike the languid of a metal pipe, it cannot be raised or lowered after the pipe is put together. The upper lip is chiseled out of the front board and, like the block, once in place cannot be moved.

The top of the pipe may be closed with a plain cap that is glued in place, but more likely it has a close-fitting stopper shaped as in fig. 30. If it is an open pipe, it may be cut off square as in fig. 26 or fitted with a movable slide as in fig. 31. Small open wood pipes usually have a soft metal flap set so that it folds down over the open end, partially closing it.

Round and triangular pipes of wood and those with double mouths exist but are rare. Most pipes are rectangular with a single mouth on one of the narrower sides.

4

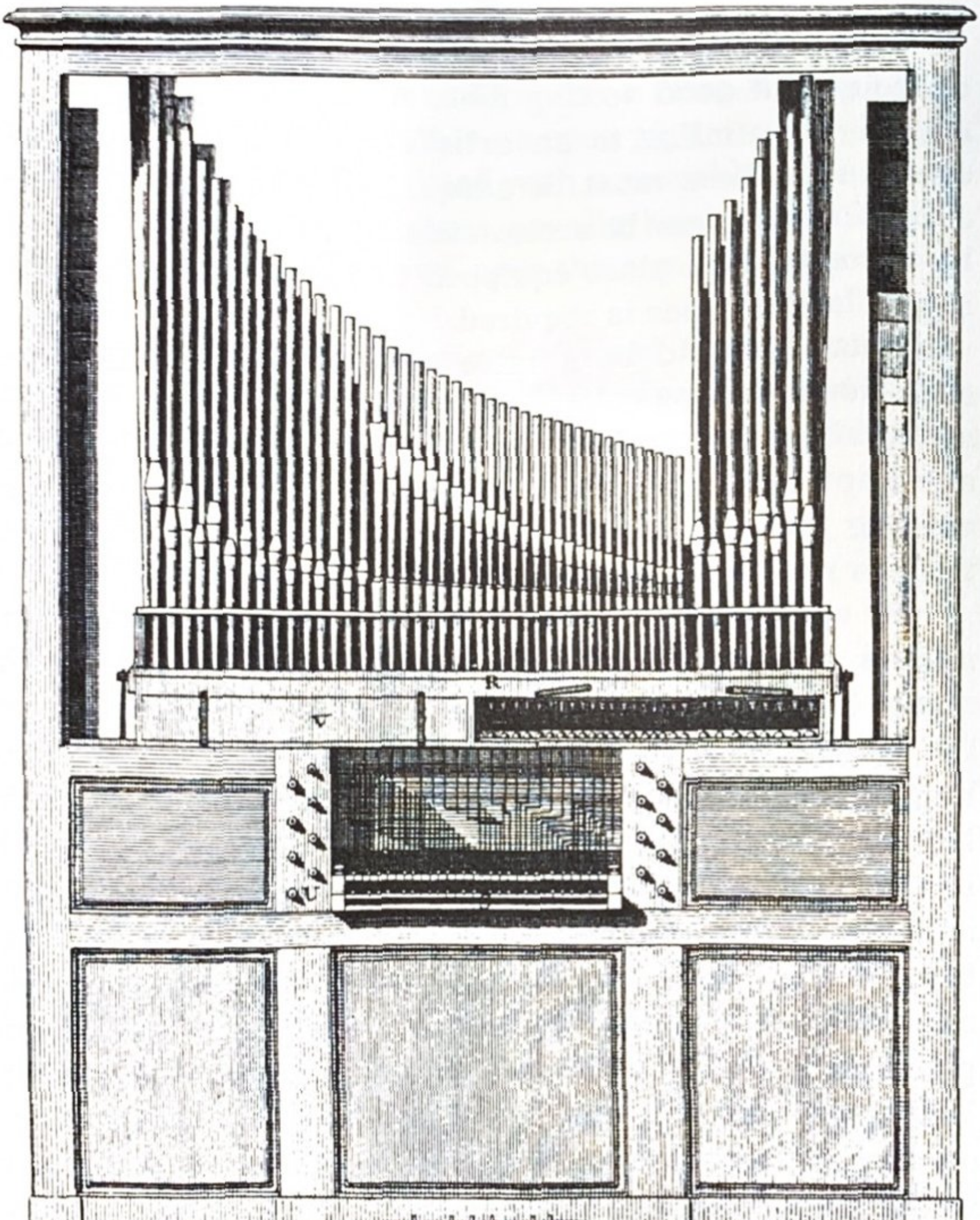
Preparation of Pipes for Voicing

After new pipes are washed and dry, they are ready to be voiced. A good voicing room should be spacious, clean, and light, similar to an artist's studio with a northern exposure. There must be adequate head room so that an eight-foot stop can be accommodated with ease. Additionally, a convenient place equipped to accommodate the voicing of larger pipes is required.

There should be a table or work bench sufficiently capacious to lay out an entire stop in one row. The table should be separate from the workbench where voicing tools are kept and used, but it should be near both it and the voicing jack. Tools unique to voicing are described in the text as needed to explain their shapes and uses.

A voicing jack is a workshop organ which provides means to set quickly any desired wind pressure, rack space for pipes to be voiced, a keyboard and stop controls for playing the pipes, and a tool tray at a comfortable height. Desirable but not necessary are latches on each key so that any key or combination of keys may be locked in the playing position quickly; likewise a tuning stop built into the voicing windchest will be found highly useful. The tuning stop needs only two or three octaves and requires no virtues beyond clarity and stability. The cabinet organ pictured in fig. 32 is of the right size for use as a voicing jack. However, the jack does not have a pedal clavier, enclosing casework, or a second manual, and the pipes would be set lower to the manual clavier than in the cabinet organ.

The voicing room must be located in a quiet area where machinery noises do not interfere with listening to pipes. If the pipe sounds carry into other areas, then the



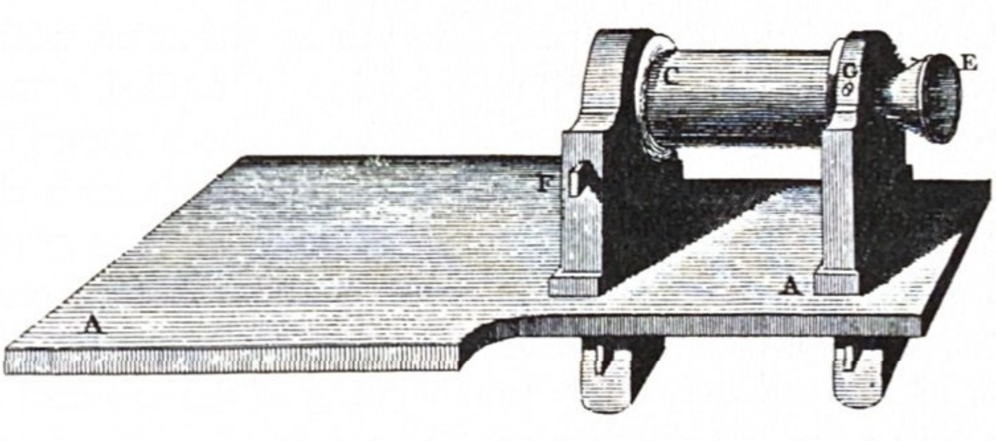
32. Cabinet organ of a size suitable for use as a voicing jack.

room should be made soundproof. If so, it should then be well ventilated.

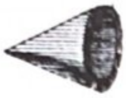
The stop to be voiced is laid out on the work table where much of the work of voicing is done before pipes are transferred to the voicing jack.

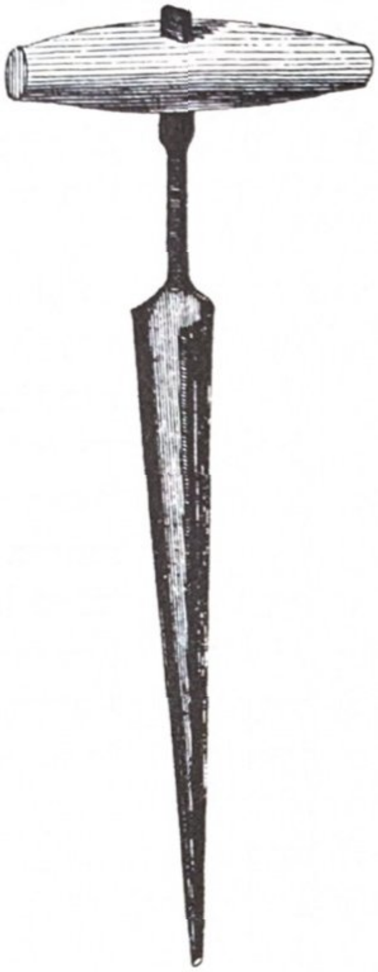
The first shaping operation is to round the toe so that, when the pipe is placed on the windchest, it is tangent to the counterbore of the toe board. This permits the pipe foot to seal the pipe to the wind.

The toes are rounded by using a toe cone lathe (fig. 33). In the modern version of this tool, the drum is turned by an electric motor. (The tool as it is shown in the engraving is operated by winding a cord attached to a bow which is wound around the drum. The bow is pulled back and forth by an assistant while the voicer pushes the toe of a pipe into the revolving cone [figs. 33 (*E*), 34], the rotation of which burnishes the metal and gives it a rounded contour.) The modern version of this tool has several cones linked together with a belt drive so that the pipe can be moved from one to the next in sequence for the extreme rounding of the toe necessary for closed-toe voicing. Beginning with the most acutely tapered cone, the toe is forced into the cone, which causes the end of the foot to become



33. Lathe for shaping the toes of pipes.

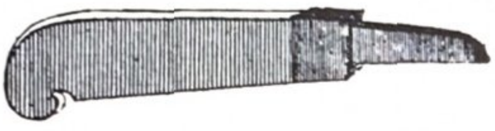




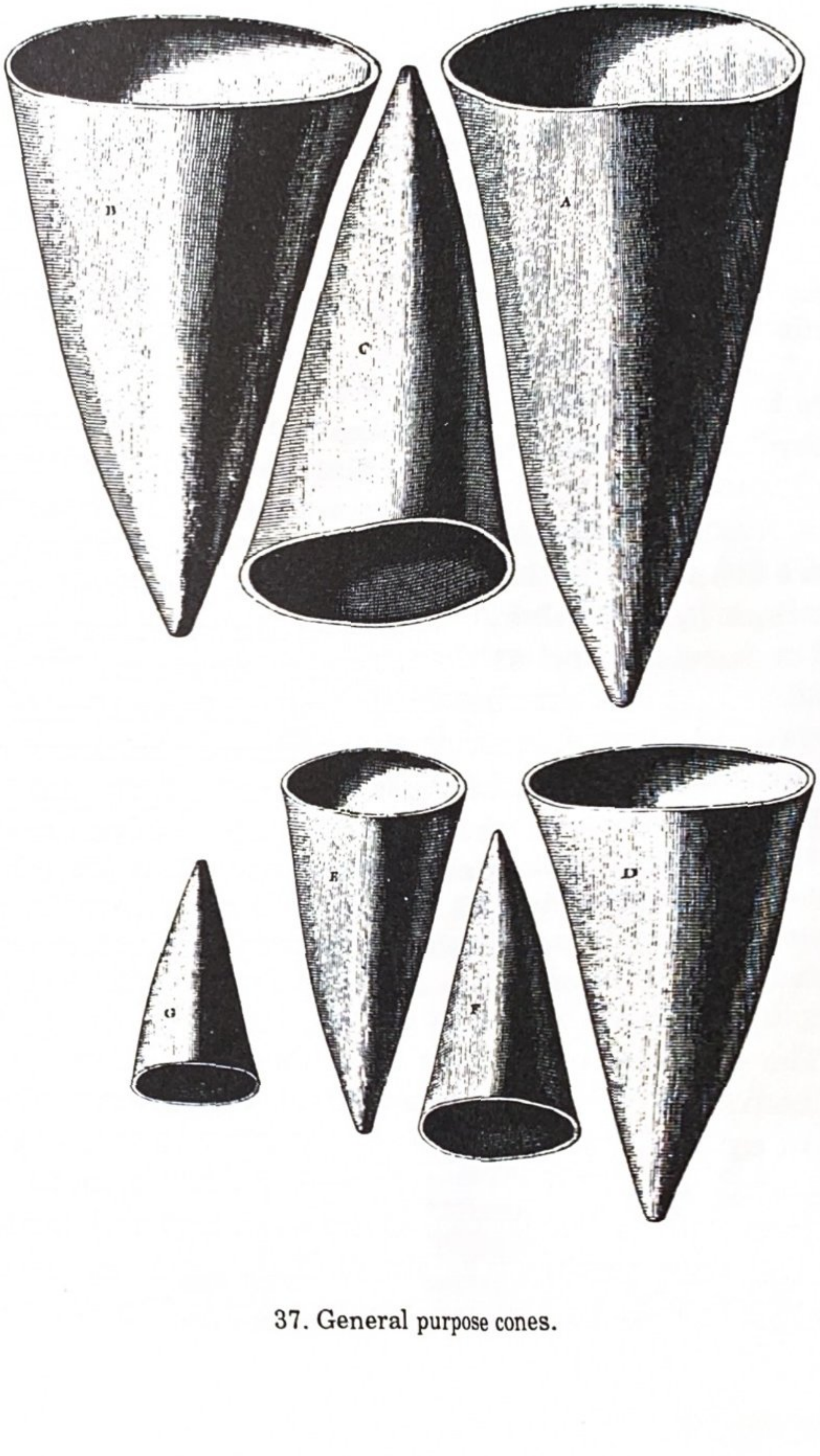
34. Above: detail of lathe cone.

35. Right: tapered shell bit or reamer.

36. Below: small general purpose knife.



rounded and the opening made smaller. The hole in the toe is opened to its correct size with a tapered shell bit (fig. 35), and a small knife (fig. 36) is used to trim the end of the toe, which is then given a smooth countersink with a deburring tool or cheese bit (mounted in a handle), removing all burrs both inside and out. The toe hole gauge (Pl. IIa), a tapered metal mandrel similar to a jeweler's ring gauge, is used to smooth the inside of the hole. It is graduated in millimeters for this purpose. An obtuse toe cone is used to remove the outside burr. A set of toe cones (see fig. 37, Pl. IIa) is used for the final shaping of the toe and for rounding the top of the pipe. The toe is chamfered to a smooth bevel which insures silent entry of wind into the



37. General purpose cones.

foot and helps keep wind turbulence below the languid within acceptable limits.

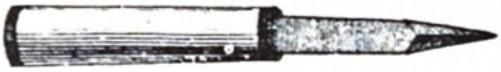
Pipes are laid in a cradle to hold them as they are cut (see Pls. IVa, IVb, Va). For smaller pipes the cradle is made by cutting v-shaped grooves of different depths along the four sides of a hardwood board about one meter long and 10 cm. square. The largest groove is padded with thin felt. Larger pipes are spanned across two yokes, each shaped like a letter Y, that are dropped into square holes in the workbench.

If the mouth of the pipe was not cut away from the body before it was soldered together (see fig. 15), this process must be performed now so that the dividers can be used to mark the cut-up on the upper lip. The upper limit of the cut is defined with a scratch marked with proportional dividers. It is always gauged conservatively to be less than the final cut-up. A steel straight-edge may be laid across the pipe at the mark to guide the cut. The pipe is slashed across the mouth with a small pointed knife just above the languid, cutting not quite through the metal. After cutting the line of the lip, the point of the knife is dug into the edge of the mouth along one side, and the scrap is gently pried up and broken away. With the mouth opened up slightly in this way, there is clearance for the points of proportional dividers to be used to mark the cut-up and for the blade of the cut-up knife to reach the edge of the upper lip.

The surface of the pipe most vulnerable to damage is the leading edge of the languid bevel. This is the surface that in opposition to the inside of the lower lip shapes the front and back of the windsheet. Any damage to these surfaces will alter the shape of the windsheet and consequently the timbre or the attack of the note—or both. Nothing must be permitted to touch either of these surfaces accidentally. It is essential to guard the flue when prying out any scraps of metal that are cut away from the mouth. These scraps tend to curl right into the flue almost as if deliberately.

Proportional dividers are used to mark a line on the upper lip to locate the cut-up. After the dividers are set to the correct proportion, the width of the mouth is measured at the flue with the longer points as illustrated in Pl. IIIa. Care is required not to touch the languid. The dividers are reversed, and one point is laid against the top edge of the lower lip. The points are drawn across the mouth to make a fine scratch on the upper lip, letting the lower point slide along the top of the lower lip. On small pipes a short scratch is all that is necessary.

An alternative method of marking the cut-up requires the use of a chart on which the dimensions have been ruled against a logarithmic grid. The cut-up of selected samples is marked on the grid and connected with a straight line. The vertical measure is taken with ordinary dividers and transferred directly to the pipes. The upper lip of the pipe is cut with a special knife that is used for no other purpose. In shape similar to the scraper illustrated in fig. 38, the cut-up knife is bilaterally symmetrical with the point along the mid-line of the blade. It is made of tough, hardened tool steel, flat on the under surface and shaped to a fine point, with cutting edges on both sides of the taper. The angle of the cutting bevel is 45 degrees,



38. Scraper; also the shape of a modern cutting-up knife.

making the tool more of a plane than a knife. The entire working surface of the blade is polished to a mirror finish. Several sizes are necessary, with only the smallest blade requiring a fine point, which is necessary so that the tip of the blade will fit into the mouth of the smallest pipe to be cut (see Pl. IVa).

A somewhat similar knife (Pl. IIIb), used for large pipes, is made with parallel sides and a smooth rounded tip. The blade, which is about 15 cm. long and at least 2 cm. wide, is locked with a set-screw into a close-fitting slot that is milled near the end of a steel rod. The rod is set into a large handle that can be gripped with both hands and set at a right angle to it. The tool must be sturdy enough to resist bending or breaking when pulled with both hands through the thick pipe metal. The cutting edges are ground to 45 degrees for the first millimeter of thickness but are relieved to 20 degrees so that the scrap more easily slides over it. The appearance of the blade in cross section is that of a hip roof.

After the pipe is marked, it is laid in a cradle to be cut. The tip of the knife is inserted into the pipe mouth with the flat side touching the upper lip and drawn back and forth to plane away the unwanted metal (Pl. IVb). To avoid breaking the tip of the knife, use should be made of as wide a part of the blade as will comfortably fit down into the pipe mouth, but the voicer must avoid scraping the tip against the back wall of the pipe. The blade should be held so that, if the pipe has ears, they are not scored with the edge of the blade. The blade must be kept coated with a suitable lubricant that will not remain behind on the pipe to collect dust. When cutting very small pipes it is necessary to be aware of the languid, which may be thick enough to prevent the tip of the knife from going into the mouth. If so, a knife with a small radius at its tip instead of a point is used so that the languid is not scarred.

The final pass or two with the blade should just split the line scribed on the upper lip. As the scrap curls up on either side of the mouth it is cut away; this is done by using the cut-up knife turned vertically. If the scrap is too bulky to be planed away, it is first trimmed with a small saw made from a strip of steel about 1 cm. wide and then planed with the knife blade. Both sides of the mouth and the lip must be left square and smooth with all scrap and burrs removed.

After the scrap is cleaned away, the pipe should be inspected to determine that the upper lip is cut parallel to the lower lip and that the sides of the mouth are cut straight. A thin, flexible steel blade such as a lancette (Pl. IIIb) should be slipped into the pipe and wiped across the inner edge of the upper lip to remove the fine burr left by the cutting of the metal. The outer edge may be burnished smooth as well, unless the lip is skived, or cut to a bevel. If the lip is cut, the knife is laid against the upper lip at a low angle and with the tip down in the mouth. The blade is drawn across the width of the lip in one smooth sweep, taking a shaving of metal. This should be repeated until the skive is judged adequate.

The mouth area of the pipe is cleaned by using a brush with short, fine bristles to remove anything clinging to the flue. Any scrap metal caught in the flue or behind the upper lip must first be removed, and in this process care must be taken to avoid damage to the languid. After these steps have been completed, the pipe may speak a musical note. The sample notes of the stop should be transferred to the voicing jack and brought to rough speech. When the sample notes have been made they should be marked and returned to the workbench where they may be used as reference for the visual setting of the flues of the remainder of the stop. If the pipes have been carefully made, the flues will be about the right size as they reach the voicer.

If the flues must be made narrower, any medium width wood chisel may be used. The edge should be sharpened to an angle of 45 degrees for later use in trimming the pipe. The back of the blade is laid against the lower lip of the pipe with the edge uppermost (see Pls. Vb, VIa); pressure is applied against the lower lip. If the pipe is wider than the chisel, it is laid first against one side, then the other, overlapping the end of the flue, and pressed against the flue as above. If the metal does not yield to pressure, the chisel should be driven against the pipe with a mallet. If the center of the lower lip remains bowed out, it is tapped lightly with a small hammer (Pl. VIb) such as those used by jewelers or with a small brass mallet. The blows are directed at the lip below the top edge so that it is not scarred.

If the pipe has ears soldered to the sides of the mouth, the chisel will need to be turned on edge after the flue is closed in the center. The back of the chisel is laid against the ear, and the opposite edge is struck with a mallet, which closes the triangular pocket left at the corner of the flue. The operation is repeated on the other side until the corners are slightly narrower than the overall width of the flue.

To close the flue of a small pipe a lancette made from an ornamental plasterer's trowel is used instead of a chisel, although the chisel may nevertheless be used (it is more awkward in this situation). The trowel is made into a voicing tool by thinning it on emery cloth, cutting the bay leaf square, and polishing both ends.

If the flue is narrow, it must be pulled open without deforming the inside of the lower lip or the languid. The lancette shown in Pl. VIIa and described above is used for this purpose by being slipped down through the flue and laid tangent to the inner surface of the lower lip. It is then pulled away from the center axis of the pipe so that the angle of the lip is not changed. The voicer must be careful since he must avoid flaring the edge of the lip outward away from the flue. If this should happen, the blade is placed in the flue and the upper lip pressed back against it so that the original configuration will be restored.

For displacing languids and for opening the flues of small pipes, one of a set of tempered steel rods (Pls. VIIb, VIIIa) may be used. The full set ranges in diameter from 1 cm. to 2 mm. and in length from 50 cm. for the smaller ones to about one meter for the larger ones, which must be long enough to reach from the toe to the languid of the largest pipes in the organ. The ends of the rods are polished smooth and the sharp corners slightly rounded so that they cannot scratch the inside of a pipe. When used to open the flue of a small pipe, the largest rod that will pass through the toe is selected. It is inserted until it just misses the languid, and the pipe is pressed against the rod so that force is directed against the inside of the lower lip. The upper lip needs to be checked to see if it lies in the same vertical plane as the flue; when the upper lip is not so aligned, it must be pulled out on one side and pushed in on the other until aligned one over the other correctly. If the misalignment is too great to correct in this manner, the pipe must be twisted until the upper lip and flue are in alignment. The point of the alignment is to enable the windsheet to graze the upper lip equally across its width. If the pipe cannot be satisfactorily straightened, it must be re-made.

To set the lip forward in a small pipe, a large rod inserted through the top of the pipe may be used, or the voicer may use any smooth steel blade that can be slipped through the mouth so that it is tangent to the inner surface of the lip. The rod is better for use in small pipes, but the blade is preferable for larger ones. In the use of the rod, one should be chosen that comfortably fits inside the body with some clearance behind the upper lip. The rod is pressed against the lip gently and moved back and forth, and care is taken to move the lip evenly.

For larger pipes, a tool with a broad blade and an offset angle at the tip (Pl. VIIIb) is slipped into the mouth of the pipe and held so that the blade is tangent to the lip on the inside of the pipe body. By pulling gently forward, the lip is moved outward. The lip may easily be ripped out of the pipe if too much force is used.

If the mouth is large enough, the voicer's hand may be used instead of a separate tool to pull the lip forward. As in moving the lower lip, the angular relationship of the lip to the rest of the pipe must not be changed. The edge of the lip must not be flared out, for this spoils the attack of the note.

If there are no ears, the flue may be "bucked open" by encircling the pipe in the hand and squeezing the sides together opposite the mouth in a controlled fashion. The object is to exert only enough pressure to cause the lower lip to begin to bow outward, stopping immediately when this begins to happen. The technique should be practiced first on scrap pipes until it is mastered.

The angle of the upper lip to the pipe body (looking from top to bottom) must be parallel or inclined slightly into the pipe. The plane of the lower lip should be set so that, rising from the bottom of the flattening, it sweeps back toward the mouth, reversing the outward angle of the cone of the foot somewhat. The inward turning should not be extreme.

The stop should now be examined. If any flue appears to be out of line with its neighbors, it should be attended to. When all pipes appear to be the same they should be transferred to the voicing jack so that the languids may be checked. Every pipe should be made to speak, however crudely, before beginning any tuning or regulation.

5

Preliminary Voicing

The position of the languid controls the angle of the windsheet and thus determines the onset of tone. The windsheet should graze the upper lip as it moves upward to dissipate in front of the pipe. The upper lip should be determined to be correctly placed for the style of voicing desired before setting the languid. Once the lip is positioned correctly, the languid may be raised or lowered to make the attack of the note coincide with the playing of the key. If the languid is high, the attack is delayed, and the note may not come to full speech in the playing of a fast passage. If the languid is low, the attack is correct, but the tone is dark and unsatisfactory.

When raising the languid, one must avoid touching the flue. A rod is inserted through the toe so that it touches the languid near one corner back of the flue. The voicer then will strike upward, using a mallet, or he will use the rod itself as a hammer. The operation is repeated at the other end of the flue. It is important that the rod should strike the languid back of the flue without touching it. The rod must not be driven into or through the flue. For very small pipes a rod should be selected that enters the toe easily and that does not bind in the foot at the languid.

Raising the languid of a very large pipe is difficult. If the pipe is already in the organ and a rod cannot be inserted through the toe, the only alternative is to accept in advance that damage to some degree to the front of the languid cannot be avoided. The least upsetting way to do this is to use a thin steel blade that is as wide as will still fit through the flue with which to pry up the languid. The smallest amount of force that can be used should be applied, distributed as widely as possible. If the leading edge of the languid acquires a burr, it may be flattened somewhat by running a smooth, hard tool along it; however, once such damage is done, it is impossible to repair perfectly without removing the lower lip.

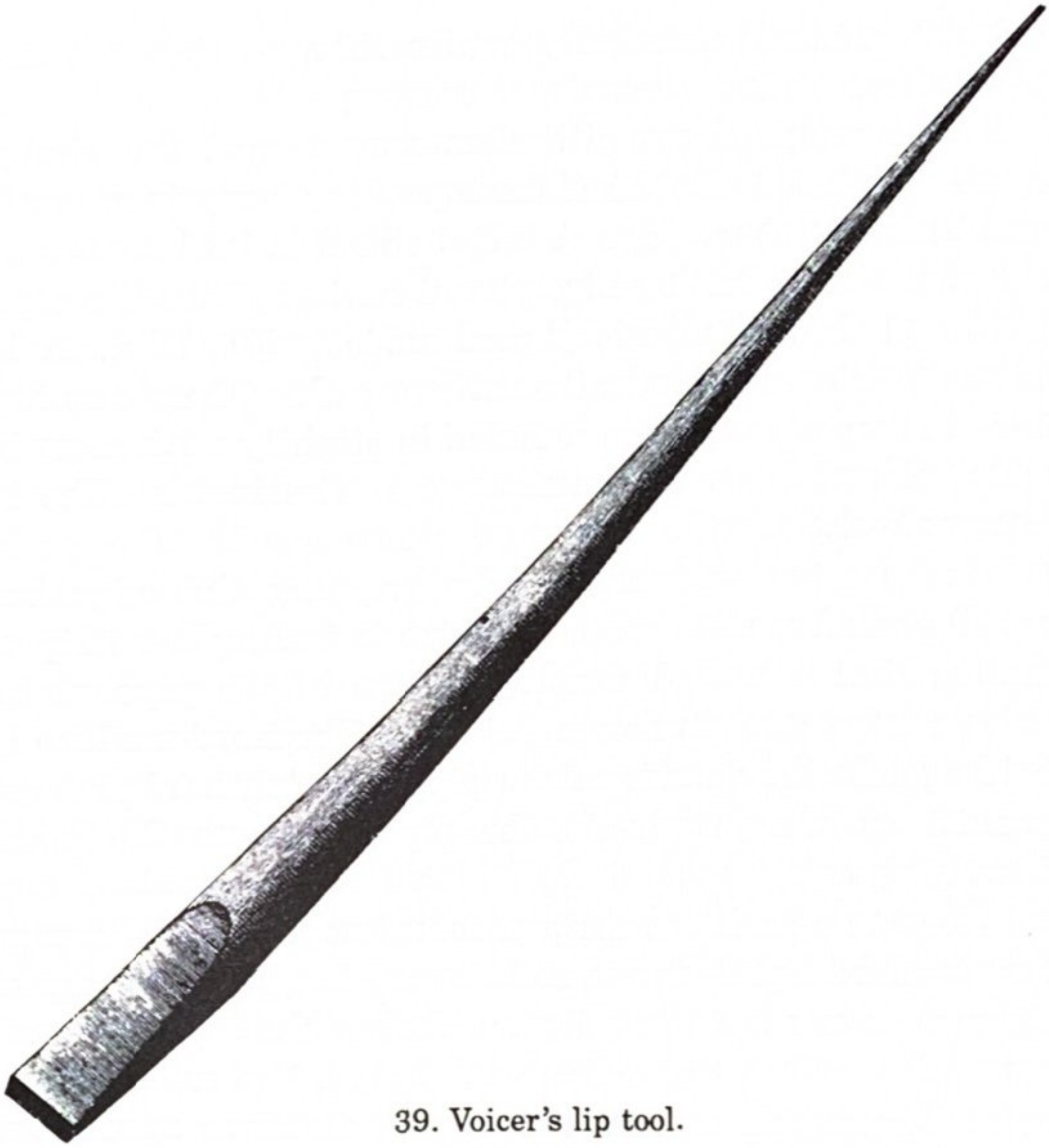
Putting the languid down is less difficult than raising it. For smaller pipes any of the rods long enough to be lowered through the body to touch the languid may be used (Pl. VIIIa), and a slight tap on each corner will be required. For larger pipes, a lip tool (fig. 39) or a short rod (Pl. IXa) is set on the front of the languid on one side and struck with a mallet; the process is then repeated on the other side.

The steps described above result in all pipes being made to speak somewhat similar notes. Upon completion, the stop is ready to be regulated, after which it may safely be cut to length for the initial tuning.

The first cutting to length is done at the beginning of the regulation of the stop after each pipe speaks its true tone as it is played on the voicing jack. The dead-length pipes are cut first, beginning with the lowest note and its octave. Each pipe is trimmed using a saw with a fine-tooth blade until it is just under pitch when cool. From these first two notes the lengths of the other dead-length pipes may be calculated using the general formula

$$\sqrt[a]{\frac{x}{y}}$$

where x = the tuned length of the longer pipe, y = the tuned length of the shorter pipe, and a = one more than



39. Voicer's lip tool.

the number of pipes between x and y. These values should be rounded off to the next higher millimeter and used to measure the lengths of the pipes between the sample notes. If the pipes are fitted with tuning collars, they may be cut a little shorter than if they are to be cone-tuned.

Roll-tuned pipes are left over-length so that each one is longer than its tuned length by about one diameter. The formula should be adapted to take this factor into account. The cutting formula must be used with care, especially if the halving ratio of the stop is not linear. It is better to recalculate at least once every octave than to risk cutting pipes short.

After a pipe is cut with shears or a saw, the sharp edges are planed off so that the top of the body is smooth and without a sharp edge. A broad chisel is laid on top of the pipe with its cutting edge placed so that when the pipe is turned the top edge is planed smooth (Pl. IXb). It is better to take several small shavings rather than one big one. The top of the pipe is rounded in slightly with a cone, which smooths over the outside edge. The inside edge is left unaltered.

Large pipes are smoothed by gripping the edge between a wood or metal plate to which is fastened a strip of leather that is turned around the rim of the pipe or by using a large cone, as shown in Pl. Xb. The hard surface is held against the outside of the pipe; the leather, pressed against the rim just inside the pipe, protects the hand from being cut.

The tuning roll is a strip of metal at the top of a pipe that is rolled tightly into a coil. It may begin at the top of the pipe or be cut a short distance below the top. Approximately as wide as the radius of the pipe, the roll is made by scribing a pair of lines the correct distance apart and parallel to the body at the top of the pipe but extending the length of the diameter or a little more. The scribed lines are deepened to about half the thickness of the metal with a knife. If the roll does not begin at the top of the pipe, it is cut free with a saw cut across the top of the scribed lines. The top end of the roll is pried up from the body and gripped with round-nose pliers across the tip. The pliers are used like the key of a sardine can to wind up the metal into a tight coil (see Pl. XIa). On large pipes there should be a strip of thin felt rolled up into the coil so that it will not buzz when the pipe plays.

The voicing of wood pipes is far simpler than those of metal, since the process is virtually built into the pipe when the boards are cut and planed. If the sides and mouth are put together straight and true, all that remains for the voicer to do is to file away the upper lip until it is smoothly shaped and to cut open the flue in either the block or the cap. The languid or block, as it is called, cannot be moved since it is glued solidly into the base of the pipe.

The toe may be fitted with a soft metal tip. If so, it is shaped as if the whole pipe were of metal. If the toe is entirely of wood the voicer must cut thin wedges of similar wood to slip into the toe for the final regulation. These wedges are kept in place by friction alone.

The cap, equivalent to the lower lip of a metal pipe, is made of hardwood which is fastened to the front of the block. In some styles of voicing the windway is cut into the cap instead of the block. This is done by carving out a groove that will direct the wind around the front of the block and upward toward the lip. If the windway is cut into the block, its front may be cut away with a sharp chisel. The last bit of the front edge of the block is cut vertically so that the actual flue has two parallel sides. The flue is opened appropriately, using a fine, broad file. It must be made the same width all across the front of the block. The ends of the flue are not extended to the sides of the pipe; a small closed area on both sides is left intact so that it is about 5% shorter than the width of the mouth.

The upper lip is planed out of the bottom end of the front board, cut off at the right height and sanded smooth. The lower lip may be left square or rounded as long as the edges are smooth.

Large wood pipes are fitted with ears made from blocks of wood of the same thickness as the sides of the mouth; these are glued in place. Smaller pipes do not need ears since the sides of the body that project beyond the upper lip serve the same function. If the mouth is confined too closely by the side walls in the upper register of a stop, the inside corners may be cut away at an angle by using a chisel or knife; however, the outside surfaces of the sides must not be cut away.

Nicking in the windway of wood pipes is done with a fine knife-edge file. The file marks are usually cut about 15° off the vertical axis of the pipe. They are otherwise similar to nicks in metal pipes.

Wood pipes are usually cut to length by the pipe maker, but open stops need to be trimmed by the voicer. Any fine toothed saw may be used; thereafter the edges are sanded smooth.

Wood pipes are tuned in several ways. An open pipe may be cut shorter than dead length, after which the top is partly covered with a small board nailed in place. A small pipe is fitted with a soft metal tuning flap set into its top along the back edge. A saw cut the width of the thickness of the metal is made that extends down about 1 or 2 cm. parallel to the back of the pipe in its rear board. A piece of pipe metal long enough to fit into the slot that covers the top of the pipe is inserted into the slot and fastened with one or two small nails. The flap thus fitted is folded forward and may be left straight or rolled up as desired.

Large pipes may be cut slightly over-length and fitted with wooden slides (see fig. 31). The slide is held in place with a set screw or nail. Stopped pipes are either covered with glued-on caps or fitted with movable stoppers.

6

Regulation

The creative part of voicing begins with the regulation of the pipes. The loudness, attack, and tone color of each pipe are evaluated in a deliberate and methodical way, organized so that several things are done at the same time. Patterns of playing notes are used which expose the differences among the pipes efficiently and which direct the voicer's attention to those items that should next be taken up. These patterns enable the voicer to move quickly around the keyboard and to avoid hearing the notes in any particular musical key. It is important to remain detached from any sensation of tonality and to select notes seemingly at random.

The first playing through is from bottom to top of a chromatic scale to find any pipe which does not speak or which speaks a false note. A pipe with a high languid will come to speech very slowly or not at all; the languid should be brought down until the tone is firm and the attack secure. A pipe that speaks its octave or other harmonic pitch has a low languid, which should be raised just enough to settle the tone on the fundamental pitch.

If the widths of the flues have been graduated evenly throughout the compass of the stop there should be no unduly loud or soft notes. No particular attention is given to the timbre at this time. When all the pipes are speaking, they should be cut to length and tuned, leaving each one slightly flat.

As soon as the whole stop is playable, sample notes should be established as reference pipes against which all of the others are compared. When this process is executed, a playing pattern is followed that permits the comparison of every unregulated pipe with at least two sample pipes, one above and one below the note being evaluated.

In practice, this is done by comparing the highest and lowest pipes with any samples already set in the middle register; particular attention must be given to their loudness, after which a few intervening notes are set so that there is no unregulated span of notes greater than an octave. Then each octave is broken into two parts, either by selecting the diminished or perfect fifth as the middle note. Some voicers prefer to divide the octave into three parts by establishing a series of sample notes a major third apart. However the notes are selected, each new note is compared to at least two other regulated notes. This process is continued until at first an arpeggio of major thirds, then a whole-tone scale, and finally a chromatic scale are played. Each of these groups of notes as played will alternate from regulated to unregulated notes in succession.

When playing the notes, the voicer should avoid connecting them; he should permit a brief moment of silence between each pair by using a detached touch. Each note should be dwelt on long enough for it to develop its full speech, and then there should be a pause between notes to permit all resonance to die out. When playing a whole-tone or chromatic scale, any set pattern that will establish a key feeling should be avoided. It is best to move about at random.

The most obvious faults should be attended to until the whole stop is reasonably even. Then each octave is taken in isolation and regulated until it seems to need no further refinement. When each separate octave has been smoothed out, the playing pattern should change to encompass the whole stop as it is played in whole or half steps. Once again the most obvious faults are corrected first, and the process continues until there are no more obvious faults remaining.

Refinement, when it is finally achieved, will have been done gradually and smoothly until it no longer seems worthwhile to continue the process. This will be apparent when the stop has become musical throughout, for nothing will remain to offend the ear in any playing combination that may be used.

As the regulation begins, the loudness from note to note is first attended to, for changes in loudness also affect the attack, pitch, and timbre of the note. The first determination of loudness has been made previously when the cut-up of the stop was set and the pipes examined on a workbench to insure the even progression of mouth height from bass to treble. If the width of a flue is changed, it should not be made noticeably different from its neighbors.

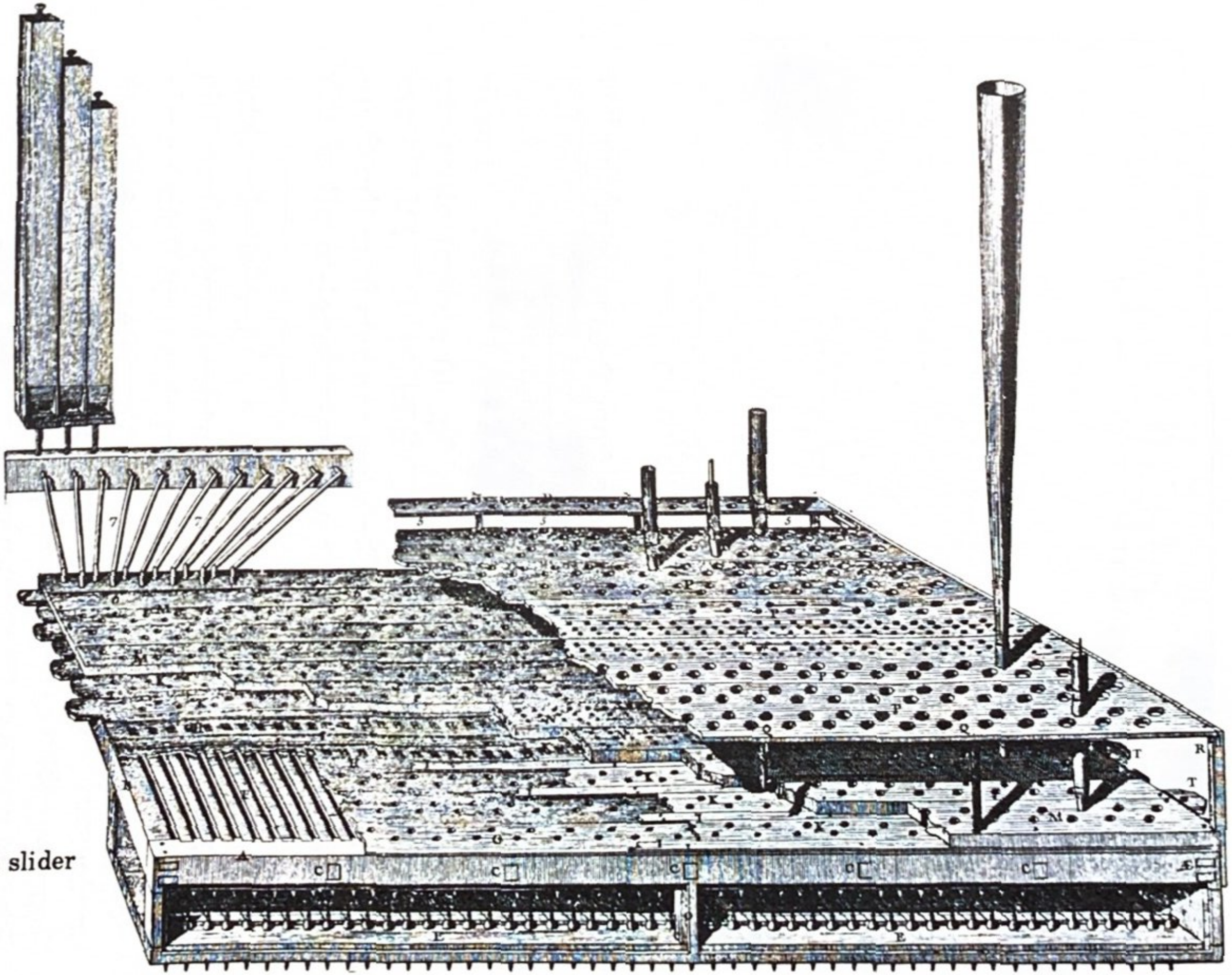
In the lower register of open stops the amount of wind at the toe may need to be reduced to soften the pipes, or the cut-up may need to be raised, especially if the last few notes drop off sharply in volume in comparison with the tenor and mid-range. If a principal is made with a 2/7 cut-up at c′, the cut-up of C will need to be slightly greater than 2/7 unless the wind is reduced at the toe, and the cut-up of CC may need to be raised to as high as 1/3 if the note is to be stable.

Within the limits of the established cut-up values, in a well-regulated stop the flue width should graduate imperceptibly from wide to narrow as one moves up the scale from bottom to top.

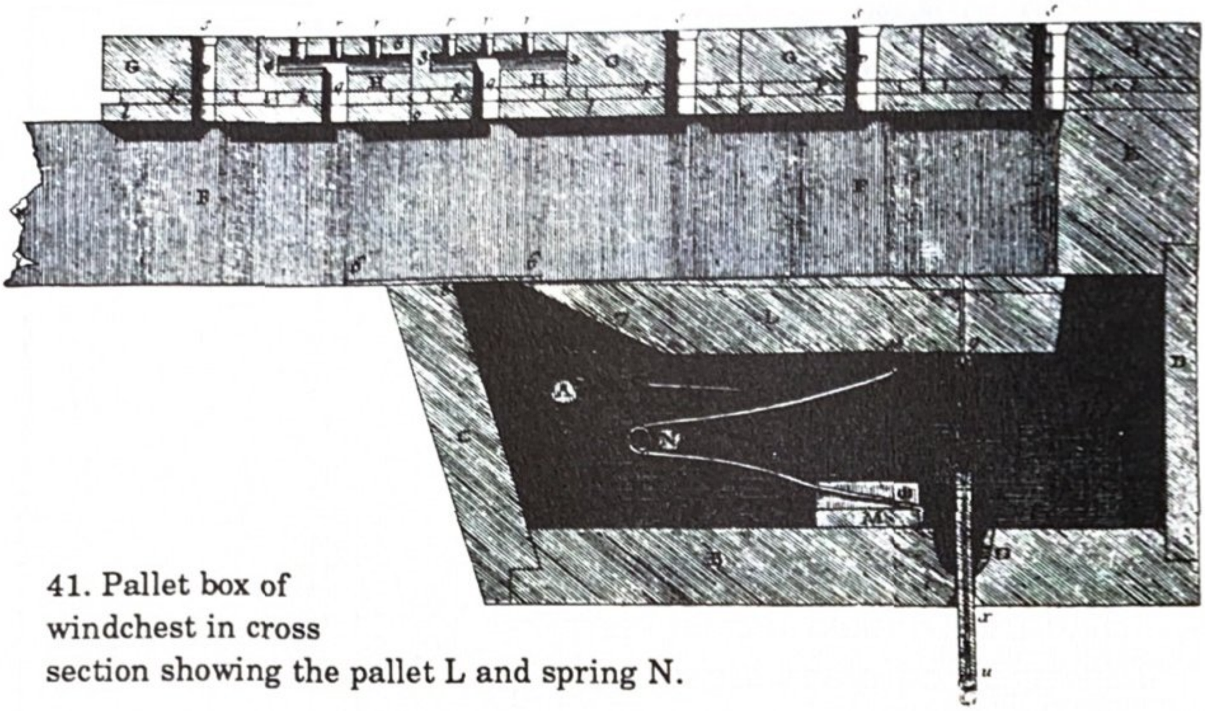
To examine the attack of the pipe, the voicer should play each note in turn from bass to treble by repeating each one in a rhythmic staccato fashion, ending with a sustained note. It is important to establish a tempo for the note pattern, which is played the same way each time, increasing the rapidity of repetition the higher the pitch. If any pipe fails to repeat crisply, the languid is probably high and should be brought down until the attack of the note is heard to coincide with the striking of the key. Allowances should be made for larger pipes, but upwards from G in the tenor register of an open stop the attack of the note must not lag behind the playing of the key. There should be no delay in any register of stopped pipes. When drawn in any common registration, the rate of repetition in all registers of any stop should permit clear and musical playing of any trill, arpeggio, or rapid scale passage with each note being heard distinctly.

The timbre of an open pipe is most pleasing when the languid is level with or only slightly higher than the edge of the lower lip. For stopped pipes it should be slightly lower. If the languid is driven lower than necessary to attain a crisp attack, the timbre begins to darken, losing its upper partial tones. Eventually the pitch of the note will leap up an octave—or, if the pipe is stopped, a twelfth—and will need to be blown harder to maintain its speech. If there is any detectable loss of tone color or if the pitch jumps up to a harmonic, the languid should be raised. The best way to find the point of optimum speech is to raise the languid until the onset of speech begins to lag, and then to lower it only far enough to restore the attack.

Different types of windchests affect pipe speech in different ways. The common type of windchest in Dom Bédos' time was the slider and pallet chest, as seen in perspective in fig. 40. Fig. 41 shows a cross section through the chest and pallet box. The pallet (*L*) pivots on its back end as it is opened by the pull wire attached at *g*,



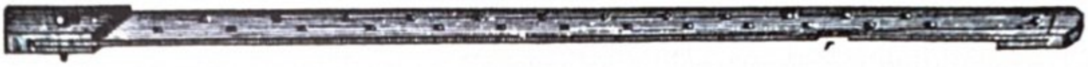
40. Typical slider and pallet windchest.



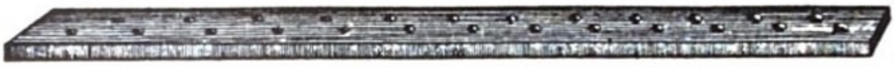
41. Pallet box of windchest in cross section showing the pallet L and spring N.

admitting wind under pressure from the inside of the box *A*. The wind flows upward into the channel *F* (see also fig. 40 [*F*]) where it can escape only through the holes in the toe boards and into the pipes. The toe holes for the ordinary stops are shown at *p*. In fig. 40 several pipes are shown standing on their toe holes. In fig. 41 (*q*) there are two mixture stop boards. Each has one hole from the channel which is connected by a cross channel to all of the pipes of the stop.

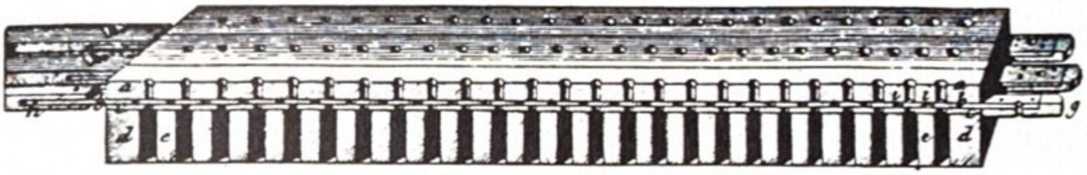
Sliders are illustrated in figs. 42–45. A single slider (fig. 42) is laid on the chest table under a stop, where it is covered by the toe board (fig. 43) for that stop. Both boards are pierced with holes that are in register. The slider is made to slip along the length of the chest under the toe board, enabling the organist to put the holes in register. Fig. 44 shows a cutaway view of a chest grid, channels, slider, and toe board with the stop in the "off" position. Fig. 45 shows the same windchest with the stop turned "on."



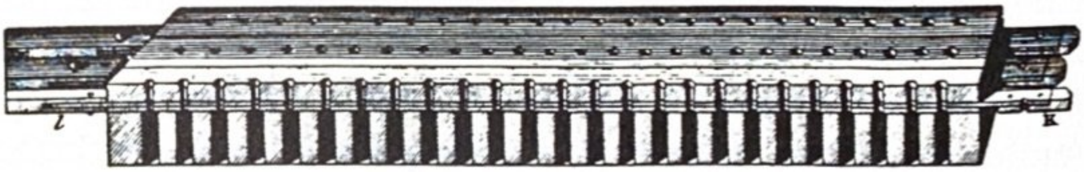
42. A slider.



43. A toe board.



44. Toe board above slider in the Off position, blocking the holes from the channels through the table.



45. Same as fig. 44 but with the slider open, or in the On position.

This type of windchest is still in use today with no engineering changes since the eighteenth century, although modern materials are used in ways which overcome problems introduced by the changes in moisture content of solid wood. Other types of chests in use today do not have the common key channel that is the principal feature of the slider and pallet chest. Instead of each pipe getting its wind from the same valve, each one stands over its own valve, below which is a round pallet of leather attached to a flexible leather membrane (a pouch) or the armature of an electromagnet. Some builders who use these chests will use one valve for all of the pipes of a mixture or other compound stop. This is done by cutting a cross channel in the toe board which supplies each toe hole for the stop that stands on the board, thereby giving them common wind, arranged in a manner similar to the design shown in fig. 41.

There are two distinct advantages to the key channel chest in supplying pipes with wind. The first is the smooth manner in which a flow of air is begun in the foot of a pipe as soon as the valve opens. This movement is transmitted to the flue with remarkable rapidity, moving upward from the pallet through the still air at the speed of sound. Neither the pouch valve nor the magnetic valve is capable of operating this quickly. Both types have a certain amount of inertial lag, and there is a slight backward movement of air before it flows up through the hole in the toe board. The other great advantage of the key channel windchest is the interaction in the channel of the sounds of all the pipes as they speak. This phenomenon is not clearly understood nor has it been adequately measured and described by physicists, but its effects are apparent to any voicer or tuner who has worked with pipes on such chests. The effect of the common winding is to cause the pipes to speak as one note on the attack, to lock immediately into tune, and to blend into a unified timbre that sounds as if it comes from a single complex pipe instead of from many separate ones.

In windchests with individual pipe valves, the opening of the pipe valve may generate a shock wave which reaches the languid, where it momentarily deflects the windsheet outward away from the upper lip. When a smooth flow of air is established, the windsheet behaves normally, but the effect of the displacement is to delay the attack of the note, making the note behave as if the languid were high. Without being able to change the method of delivery of air to the pipes, the voicer must compromise between having a slow note with good timbre or a prompt note with a darker tone than is wanted. In compromising, the timbre of the note suffers since it loses some of its upper partial tones.

Changing the loudness of a note by changing the width of the flue of a pipe alters the timbre slightly. This must be taken into account during regulation. If the flue is opened the timbre is made brighter, and if the loudness is satisfactory the cut-up must be raised slightly to bring the timbre back in line with other notes in the same register. If the flue is closed, the timbre is darkened; the flue should be opened a little and the cut-up raised, which will alter its timbre somewhat though the note will speak more quietly than before. In using this method to control timbre, any alteration to the cut-up should be very slight. If the lip is cut too high, the note will become extremely troublesome and may refuse to speak a normal note. Such an occurrence means that the pipe must be rebuilt.

When in the nineteenth century higher wind pressures came into general use, several techniques were developed to compensate for the adverse effects of high pressure wind on pipe speech. These included the closing of the toe hole to reduce the wind pressure in the foot, the placement of a stabilizing device in front of the mouth, the deep nicking of the languid (even of the lower lip), and the cutting of a narrow slot set a short distance below the top of the pipe.

The wind pressure of the organ determines the velocity at which the windsheet moves past the mouth of a pipe. Under ideal conditions there is little or no reduction of pressure until the air reaches the flue where it is compressed and speeded up to form the windsheet. The wind pressure inside a pipe foot will be the same or slightly less than that of the wind channel below the toe board, but this will be so only if there is no constriction at the toe of the pipe. The pressure in the foot of a typical pipe while it is speaking its normal tone is no more than approximately 65 mm. of water in a U-tube. It is often less but rarely falls below 45 mm.

If the chest pressure is increased, the toe must be closed to prevent the foot pressure from rising. The consequence of this constriction is the creation of eddy currents immediately inside the pipe foot that interfere with the smooth flow of air to the flue. This turbulence does not dissipate as it leaves the flue, and as it reaches the lip of the pipe the tone will be heard as less clear, less stable than it would be if there were no turbulence. If small jets of air are introduced into the windsheet, the result is a more stable tone. Notches or nicks in the languid and in the lower lip channel the wind into small jets of air; more nicks will result in more stablility of the windsheet. However, increasing the surface area of the flue adds friction which slows the windsheet, reducing the efficiency and, consequently, the power of the note. Hence in a pipe that has been nicked the speed of the windsheet can only be increased by raising the foot pressure so that it overcomes the frictional drag induced by the nicking. The windsheet becomes broader and broader, less and less able to generate a clean spectrum of overtones, and the timbre of the pipe gets duller and duller the more it is nicked.

Use of these techniques was widespread among organ builders of the Romantic and Post-Romantic eras. Each one of them degrades the natural character of the timbre, often disagreeably so, with adverse effects on the musical nature of the organ.

Two acoustic phenomena may be encountered by the voicer. If the walls of a pipe are too thin to contain the force of the resonance of the air, the walls of the pipe will respond at the frequency of the note in such a way that the pipe produces either no usable note or a quavering note. The latter condition can be detected by gripping the pipe where it vibrates most noticeably. If squeezing the pipe at this point tends to stabilize the tone, it is proof that the metal is too thin. If the pipe cannot be reinforced with an internal transverse rod soldered to its walls, it must be replaced with another one that is made of thicker metal. The other condition that is occasionally encountered is the reflection back into the pipe of its own resonant frequency by some nearby surface, either a wall of the room or the organ case itself. In this instance the reflected waves cancel the direct ones, and the only solution is either to interpose a reflective surface that breaks up or redirects the reflected waves or to move the pipe to a different location. The effect is quite rare but difficult to cope with when it occurs.

The middle register of an eight-foot open stop will speak with a noticeable amount of white noise or sputter, sounding like frying bacon. The wider the flue the more prominent these sounds are. If the organ is heard in close proximity to the pipes these sounds probably should be reduced. The most effective means is to feather the front edge of the languid by incising fine grooves by means of a pointed knife with a thin blade. The cuts must be virtually invisible to the unaided eye, and they must be sparse. As few as three and commonly no more than nine nicks will be enough to reduce the sizzle to an acceptable level.

Nevertheless, if the sizzle cannot be heard except by a listener in very close proximity to the pipes, nothing should be done about it. In any event, only those pipes that produce distracting sounds during the playing of the organ in an ordinary musical manner should be touched. These sounds enhance the blend and lend liveliness to the texture. Any amount of feathering or nicking will reduce the upper extent of the harmonic partial tones generated by the pipe. As it is, flue pipes do not generate many overtones; to reduce their number renders the timbre dead and lifeless. The object of discreet feathering is only to refine the tone to the point that it is still buoyant and musical without being vulgar.

When all stops have been regulated, the organ is raised to pitch, and the instrument is fully tuned. Voicing and tuning proceed together until the entire stop is in playable tune and on pitch. When all of the stops of an organ have been voiced separately they are placed in the organ. Then the refinements of voicing become tonal finishing, and the whole business of regulation is repeated, unless the organ itself was used as a voicing jack. The voicing is brought to a close with the fine tuning of the completed instrument.

Knowing when to stop working with a pipe makes the difference between the experienced voicer and the amateur. Certain natural components of pipe tone appear to be noise to the unskilled voicer, but to the expert these sounds signal the presence of essential elements of musical speech. The beginner tends to regulate a stop until it is too bland, all the music having been voiced out of it, as it were—a condition that produces a characterless uniformity. Voicers with a little experience but without seasoned judgment often mistakenly exaggerate the natural pipe noises to the extent that they call disagreeable attention to themselves. The most skilful voicing leaves each pipe speaking naturally, similar to all its neighbors but without any hint of seamless perfection. It is possible to find slight imperfections in any stop by listening one pipe at a time, and there may be a level of non-harmonic noise that is detectable if one's attention is called to it. All these slight differences are of no more consequence than the slightly irregular sides of the tiles of a mosaic or the spots of color in an impressionist painting. The perspective of art—whether of music, painting or mosaic—is that of the whole, not of its elements.

7

Cone Tuning

Until early in the present century organs were tuned by cutting their metal pipes to length, and re-tuning was done simply by flaring open or shut their tops. Since the metal is soft, this is not a particularly difficult thing to do. Pipes too large to tune with a cone had tuning rolls. Stopped pipes were tuned either with movable canisters or soft metal ear flaps.

When electricity was applied to organ action it became possible to put the pipes in a chamber and to put the console anywhere without restriction. Then it was discovered that if the pipes were isolated into separate spaces their temperatures often would disagree; when this happened, the organ was put out of tune. To complicate matters even more, the fluctuations were not easy to control, and it was difficult to predict when the organ would be nicely in tune and when it would not be.

There is no practical way to shift the pitch quickly of an organ by working with the pipe metal itself. The temperament and tuning of a cone-tuned organ must remain where it was originally set. After a pipe is cut to pitch, it cannot be made longer in order to lower the pitch except by soldering new metal to its top.

Organs that are built in traditional, free-standing, and encased style present no particular problem in maintaining stable pitch relationships. But if an organ is scattered around a large space with some parts of it in separate rooms, the matter of controlling the pitch becomes more complicated. Either the temperature of the separate locations must be controlled so that they vary simultaneously and by the same amount—no mean feat—or the pipes must be re-pitched to follow conditions as they change.

The answer to the problem as perceived was the invention of the tuning collar, which is a sleeve of metal that slips over the top of the pipe. It forms an extension of the metal which stays in place with spring tension but which is easy to move.

Although pipes fitted with collars may be tuned with ease, the task is a never-ending one. Seasonal tuning is the common theme for organs in chambers. When the heat goes on, some parts of the organ must be re-pitched to match other parts, and when the heat goes off the pitch requires to be put back the other way. This twice-yearly change is not possible with cone-tuned pipes.

It seemed at one time that the use of tuning collars was the ideal solution, and for some existing organs this remains true. But if the organ is placed according to the better traditions of the art, the separate divisions of the instrument are not separated from the main case; they remain all together, and control of the pitch in them is not a problem. As with other changes made in organ building a century ago, the introduction of tuning collars solved one problem but introduced others. The effects produced by these changes were not immediately perceived or well understood.

Anyone who regularly tunes organs is familiar with what a foreign object at the top of a pipe can do. In that sense, a tuning collar is a foreign object. It is difficult to shape one so that it conforms to the surface of the pipe and to itself without leaving a gap where the ends of the slide meet each other and where they meet the pipe. If the edges of the collar lap over each other, there is a gap at the top of the pipe. If the edges of the collar meet without overlapping, there is a slit open to the top of the pipe. If the collar is too stiff, it deforms the top of the pipe. If it is not stiff enough, it will not stay in place. If it is not made of the same metal as the pipe (and it rarely is), the different coefficients of expansion of the two metals cause the collar to creep out of place when the temperature fluctuates. Vibration of any sort, including the sounding of the pipe itself, may displace the collar, and it cannot be touched for fear of moving it.

There are a few even more subtle effects than those listed above. Anything attached to the top of the pipe alters its timbre, first of all because it changes the formant of the pipe resonance. A pipe of pure tin with a piece of aluminum or tin-plated coke steel gripping its open end will not have the same tone color as a pure tin pipe with nothing gripping its top. The hole created by the gap affects the amount of extraneous noise that accompanies ordinary pipe speech unless the tuning collar projects only slightly above the top of the pipe. That in itself is not necessarily undesirable, but when the collar is moved up or down, the nature of the extra noise changes noticeably. That is undesirable because it is unpredictable and consequently uncontrollable. The greater the length of a tuning collar that projects above the top of the pipe, the more noticeable the effect of moving it becomes.

Tuning collars do not behave well on tapered pipes. If the collar is long enough to fit a cylindrical pipe of the same pitch, on a tapered pipe it will be too heavy for the small diameter, and it tends to crush the pipe. If it is made to the scale of the diameter of the top of the pipe, it is usually too short to have an effective tuning range. When the collar is struck up or down in tuning it frequently loses contact with the pipe and opens up large gaps that interfere with the timbre.

Any unwanted hole in a pipe affects its speech. If it is large enough, a hole interferes with the solidity and stability of tone. The gap of an ill-fitting tuning collar, unless it is quite near the top of the pipe, causes the tone to deteriorate. The movements of cone- or roll-tuning have no such effect on the noise components of speech, and they affect the timbre only minimally. Dead-length pipes have the virtue of inherent stability. This offsets the difficulty of re-pitching them.

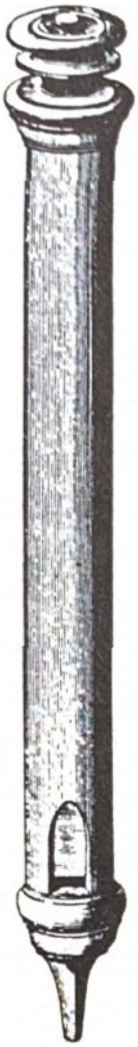
Some organ builders reinforce the sides of the mouths of pipes that are to be cone-tuned. The pipe maker scribes a line where an ear would be soldered to a pipe and makes a pass along this line with an iron to raise a bead of solder. This reinforces the pipe since the solder shapes itself into a small post and the metal of the solder bead is harder than that of the pipe. Both of these factors help to strengthen the pipe at the sides of the mouth, which is the part of the pipe most likely to crumple during cone tuning. Pipes that have ears do not need additional reinforcement.

A pipe that is cut to length in the final tuning is rounded to a circular shape with a cone. It may be left thus, but for ease of re-tuning the metal at the top of the pipe should be planed so that it is thinner. This assists the tuning cone more easily to shape the metal at the top of the pipe and relieves the stress on the mouth and foot. A small knife with a slender blade is used to pare away about half the thickness of the metal on the inside of the body, thus opening the top slightly and causing the pitch of the note to go sharp. When the note is re-tuned after the pipe cools, the top will be coned in slightly, leaving it in the proper shape if later it must be put sharp. If the pipe is not so treated in the final tuning, subsequent sharping may split the seam. Thinning the metal at the top makes such an accident less likely to occur.

When the pitch of a pipe is changed, the friction of the cone against the metal generates heat which warms small pipes enough to throw them off pitch. At the time they are tuned for the first time they will be noticeably out of tune after they have cooled to the ambient temperature. They will eventually remain in tune with patient re-touching, however. Once the tuning has been carefully set it will remain true almost indefinitely unless dust gets into the flues or damage occurs to the pipes.

The standard of pitch for organs has never been uniform. In past centuries pitches have been in general use that were as much as a major third above today's A 440 and as much as a whole tone lower. At the present time A 440 or slightly higher is in common use for pitching organs. Pitch is set with any available tool which reproduces the standard accurately. In earlier times organ builders used pitch pipes which had calibrated slides to accomodate the various standard pitches likely to be encountered (see fig. 46). The tuning fork, which came into general use during the nineteenth century, is still used today, but many tuners use the extremely accurate electronic tuners that are now available. By whatever means the pitch standard generates its note, the comparison with the organ pipes is done by ear, listening to the standard and tuning the first pipe until their pitches agree.

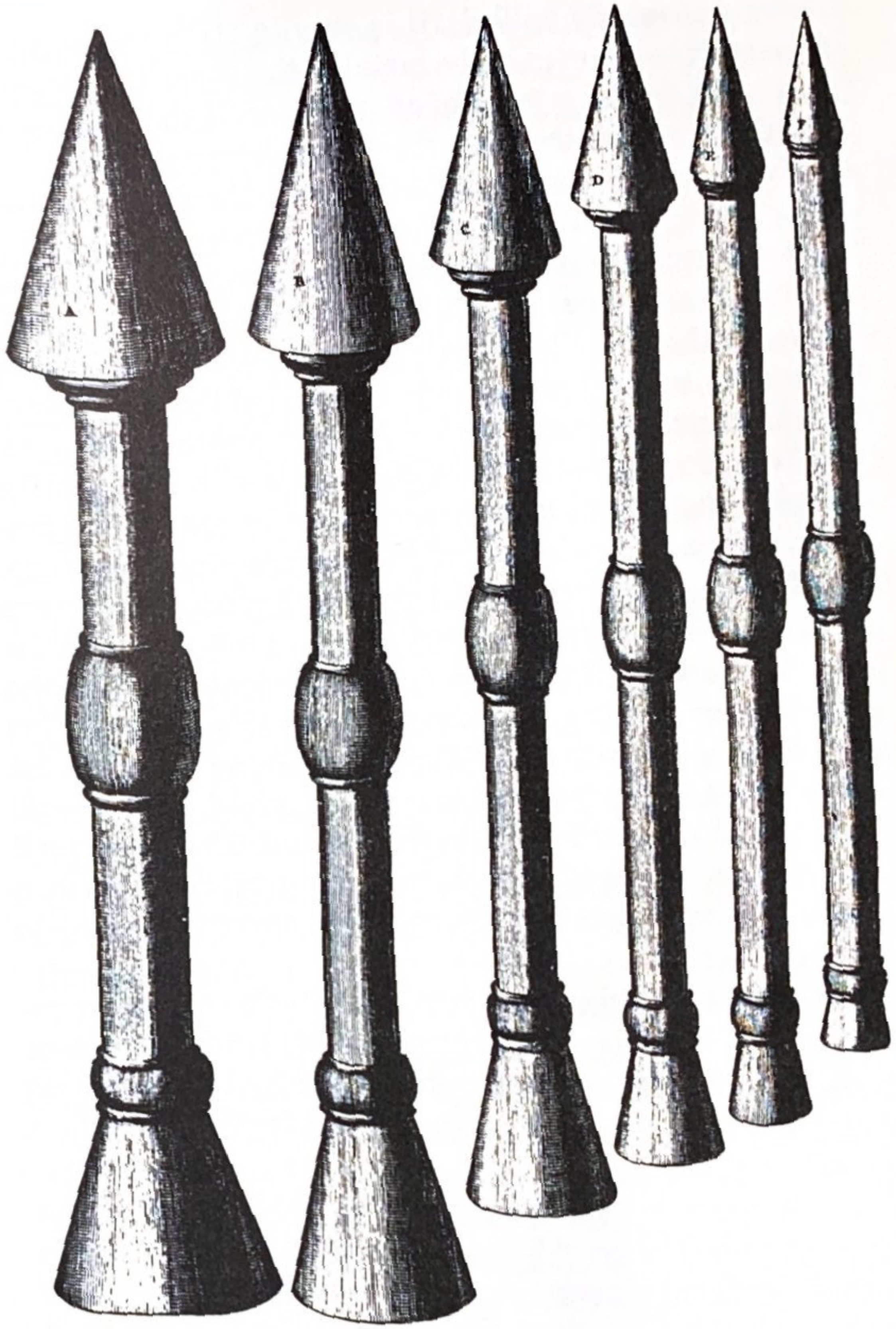
Pipes with tuning collars are tuned with any convenient bar of metal with a square edge such as a long chisel or piece of flat stock. For tuning dead length pipes, sets of tuning cones are available from any of several European supply houses. Their shape has not changed since developed in the medieval period, and their appearance is still nearly identical to the eighteenth-century set illustrated in fig. 47. They were commonly made of solid brass, but modern cones are made with wooden handles which insulate



46. An eighteenth-century pitch-pipe, forerunner of the tuning fork.

them from the heat of the tuner's hand. Metals other than brass are not satisfactory for tools that are used to shape lead or tin. Unlike iron or steel with or without chromium plating, brass does not easily amalgamate with these metals. Nevertheless, the cones should be coated with a dry or non-stick lubricant of a suitable type so that they will slide easily on the pipe metal.

A cone should be held over the pipe and kept in line with it as it is used (Pl. XIb). The pitch of a pipe is raised by centering the point of the cone over the top of the pipe and dropping it gently so that the point enters the body.



47. Tuning cones with handles.

Though seemingly unlikely, it is easy to stick the point of the cone into the edge of the metal of the pipe. This should be avoided; it is the mark of an amateur. If the amount of change is slight, the cone should be lowered until it is touching the pipe, whereupon the hand should be rotated in a small circle. The cone is not twisted in the pipe, but the point remains in contact with the pipe while the hand is rotated and pressed lightly downward. This puts less stress on the pipe than does a sharp blow. The same technique may be used with the concave end of the cone to put the note flat. While all blows on the pipes with a cone cannot be entirely avoided, the blow when necessary to strike the pipe in tuning should nevertheless be gentle and precisely struck. There is no need to bludgeon pipes into tune.

Tuning rolls must be treated carefully to avoid damage to them. While tempting to put a tuning roll down too far and then to bring it up again, such treatment damages the pipe by opening up gaps in the straight sides of the tuning roll. This not only causes difficulty in tuning the pipe flat enough but also upsets its speech. Damaged rolls should be soldered shut and re-cut in fresh metal. The tuning roll will not be damaged if it is tapped up or down with a small mallet or hammer by only the amount needed to tune the note.

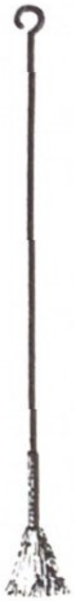
It should not be necessary to remark that no cone-tuned pipe should ever be squeezed flat, pinched shut, or torn open for lack of the correct tuning tool or trimming knife. No tuner worthy of his profession treats a pipe that way.

The tuning tab of large pipes must not be rolled into a coil but should be pried loose and pulled away in a gentle arc. If the tuner of a pipe buzzes or rattles, small strips of felt tucked into the cuts at either side of the flap are used to stop the noise.

Large pipes may also be tuned with large ears of soft metal that are soldered to the sides of the mouth. During the voicing these ears are kept parallel to each other until the pipe has been cut to pitch. Thereafter the pipe is tuned by changing the angle of the flaps, a process which changes the shading of the mouth. This method is the only way that a stopped pipe with a fixed cap can be tuned.

A temporary cap must be used to voice and tune a stopped pipe so that the note can be cut to the correct length before its permanent cap is soldered to it. A temporary cap is made from a flat piece of metal faced with soft leather which is placed on top of the pipe to seal it so that it will speak correctly. The pipe must be trimmed straight so that the leather conforms without any gap. Chimney flutes require special temporary caps fitted with chimneys of appropriate sizes. After the pipes are trimmed to pitch and are in tune wearing their temporary caps, they are returned to the pipe shop to have the permanent ones soldered on. Wood pipes are similarly treated, with the permanent caps being glued and nailed in place.

Fig. 41 (*H*) shows the channeling for a mixture or other compound stop. For each note of such stops, more than one pipe is used, sometimes as many as ten or twelve. In order to tune such a stop, all but one pipe must be silenced so that it can be heard alone with the tuning stop. Small silk mutes (fig. 48), feathers, pipe cleaners, even loose cotton or slips of paper may be used. Each pipe that is tuned is permitted to remain sounding as the succeeding pipes are opened up one by one to be tuned until the entire note is sounding at once. It is not practical to tip pipes off the wind to tune such a stop since this alters the wind flow and thus the pitch of the remaining pipes of the note.



48. Silk mute for tuning a mixture.

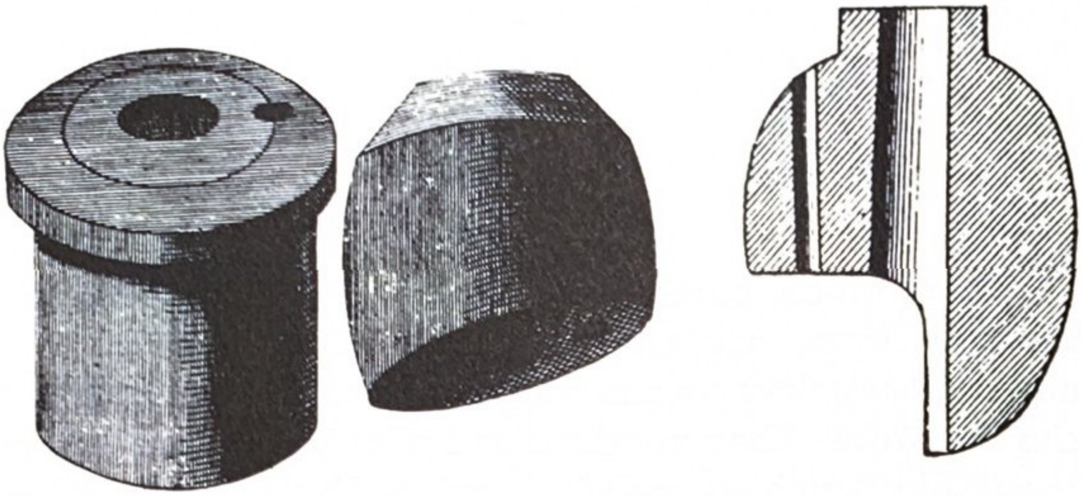
8

Reeds

Reed stops, particularly those of the Renaissance and baroque eras, are glorious affairs. Depending on their nature, they develop ensembles that stand in contrast with the fluework. They augment and color flue ensembles, and they offer a rich source of solo voices. To produce their best effects reeds must be in tune; given their nature they do not remain in tune very long. They behave something like violins, going out of tune as they are played, constantly requiring re-tuning, but the wonderful sound that they produce fully compensates for these difficulties.

Charles Fisk has described a reed as being made in two parts: (1) the motor, which contains the block, shallot, tongue, and tuning wire, corresponding to the mouthpiece and embouchure of an orchestral wind instrument; and (2) the resonator, corresponding to the "horn" held in the player's hands. The sound, produced in the motor, forces the tongue against the shallot as it escapes the confines of the boot into the resonator where it is amplified. The tongue and shallot are made of brass. Dom Bédos' engravings provide useful illustrations of reed pipes and how they are made. As with flue pipes, the separate parts are fashioned and assembled to be soldered together. Fig. 49 shows three styles of blocks, which are pinned to the resonator (see fig. 50) to hold them in the correct alignment. The pin also acts as a heat sink so that the resonator does not melt when heated by the soldering iron.

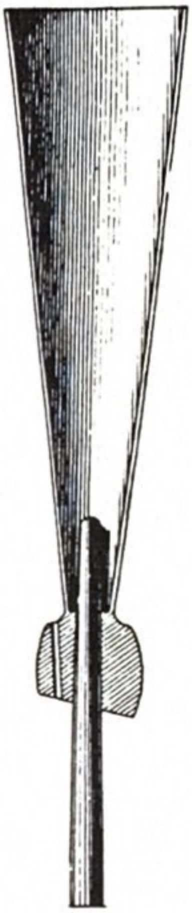
The views in fig. 51 are of the heart of any reed—i.e.,



49. Three styles of reed pipe blocks.

the motor. The motor, in turn, is supported and enclosed by the boot, which also contains the wind so that it cannot escape except through the shallot. The details of the shallot, tongue, and wedge are illustrated in figs. 52–54. Fig. 55 shows these inner parts in their working relationships. The line *A*...*B* shows how far the assembly is inserted into the block. Fig. 56 gives a view of one form of tuning wire. Other types are more elaborately bent at the lower end to accommodate the clearance of the wire inside the boot and to accommodate differing pressures according to tongue thickness and wind pressure.

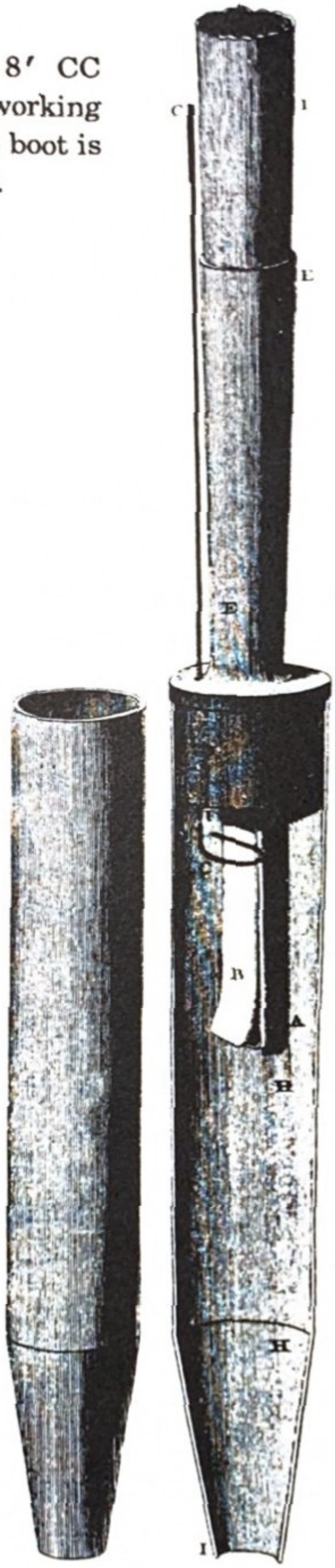
In fig. 51, the block (*D*) is bored to receive the shallot (*A*), the open side of which is covered by the tongue (*B*). The tongue is held in place by the wedge (*F*) which is driven into a groove cut out for it in the block. The tuning wire (*C*) passes through a close-fitting hole in the block which guides it as it bears against the upper part of the tongue to hold it against the shallot. The wire is made to slide up or down to change the free length of the tongue to control its pitch. The block has a socket (*E*) soldered to it into which the resonator (*I*) fits. Figs. 52-56 show the tongue, shallot, wedge, and tuning wire in several views and illus-

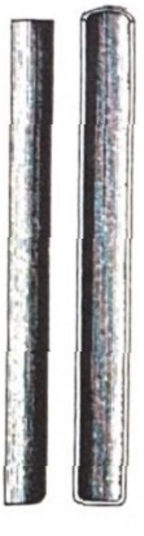


50. Cutaway view of method of soldering reed block to resonator.

trate not only their shapes with great clarity but also how they are related to one another. Motors of the same type as the one shown in fig. 51 are seen again in cutaway views at the tips of all of the illustrated pipes, but all are actually enclosed by boots. Three pipes of a trompette—the CC, c′, and c‴ pipes—are shown together in fig. 57. A cromorne and a dulzian or musette are shown in fig. 58, while fig. 59 illustrates an hautbois, a voix humaine, and a regal without a resonator. The resonators in fig. 60 illustrate a basson, which would be put on the top of an hautbois pipe, and also one of the many types of regal resonators. Wood is used for the resonators of certain types of reeds, such as a rankett, bombarde, or posaune, and for

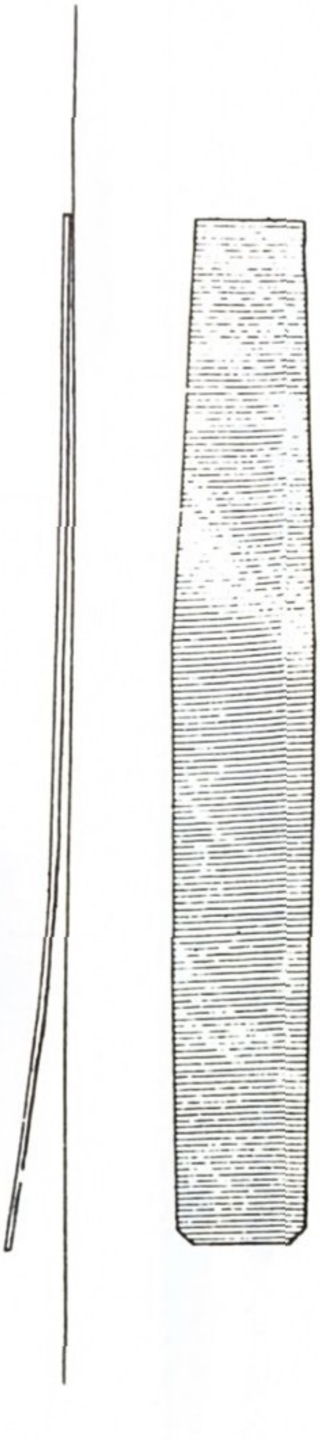
51. Right: block and socket of a trompette 8′ CC pipe with the boot shown cut away and the working parts of the pipe in proper relationship. The boot is shown complete to the left of the main view.

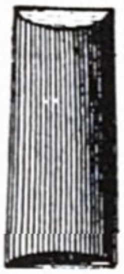




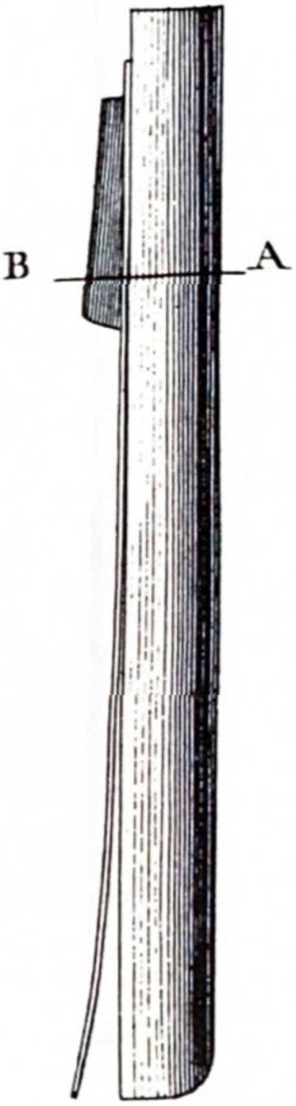
52. Above: shallot in side and front views.

53. Left, below: properly curved tongue against a straight edge, and front view.

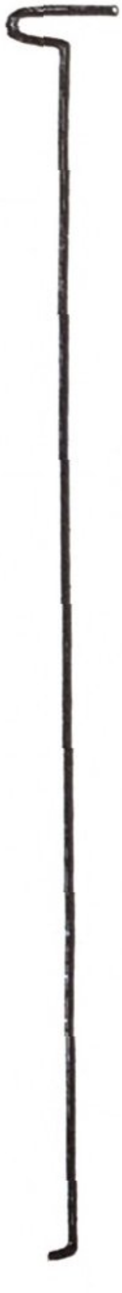




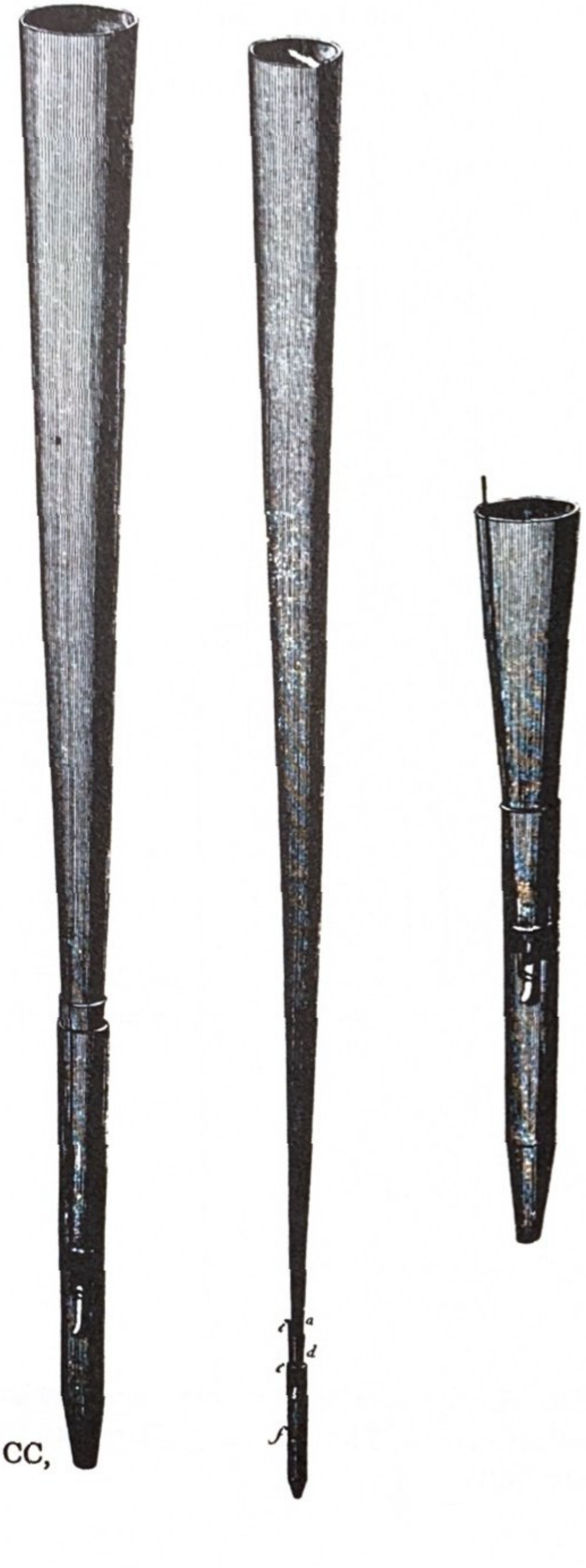
54.Center: a wedge in perspective.



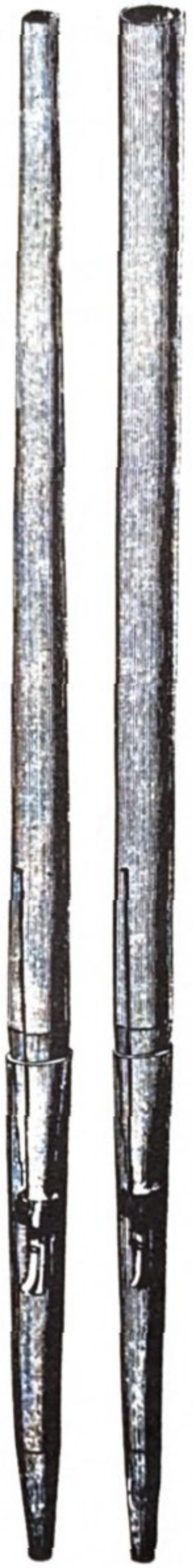
55. Right: shallot, tongue, and wedge as they appear in proper relationship. The line A____B marks the depth of insertion into the shallot.



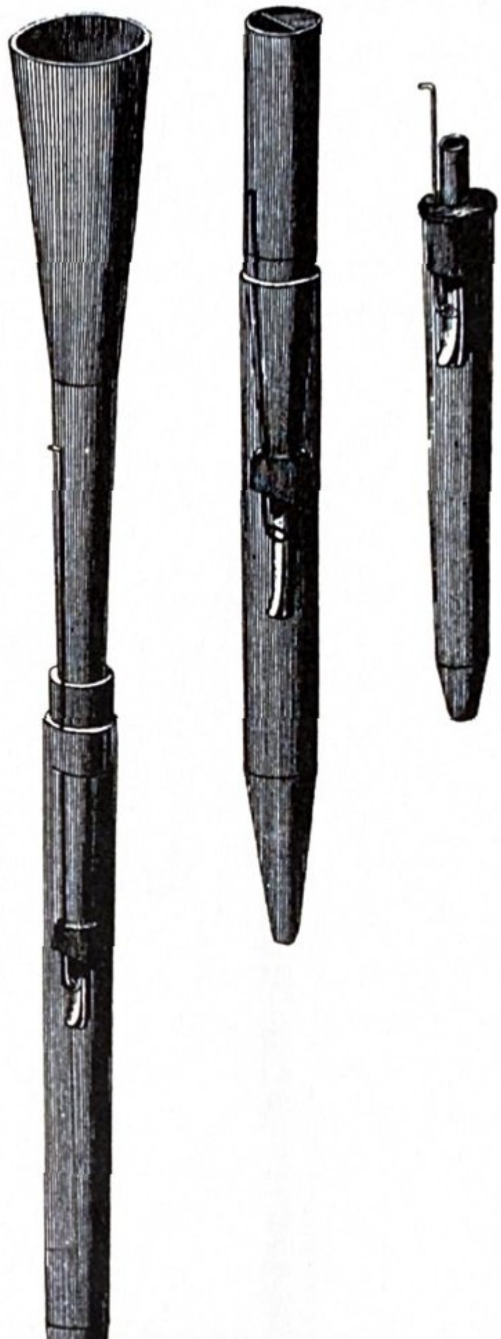
56. Above: tuning wire or spring.



57. Right: trompette: 8′ c′, CC, and c‴.



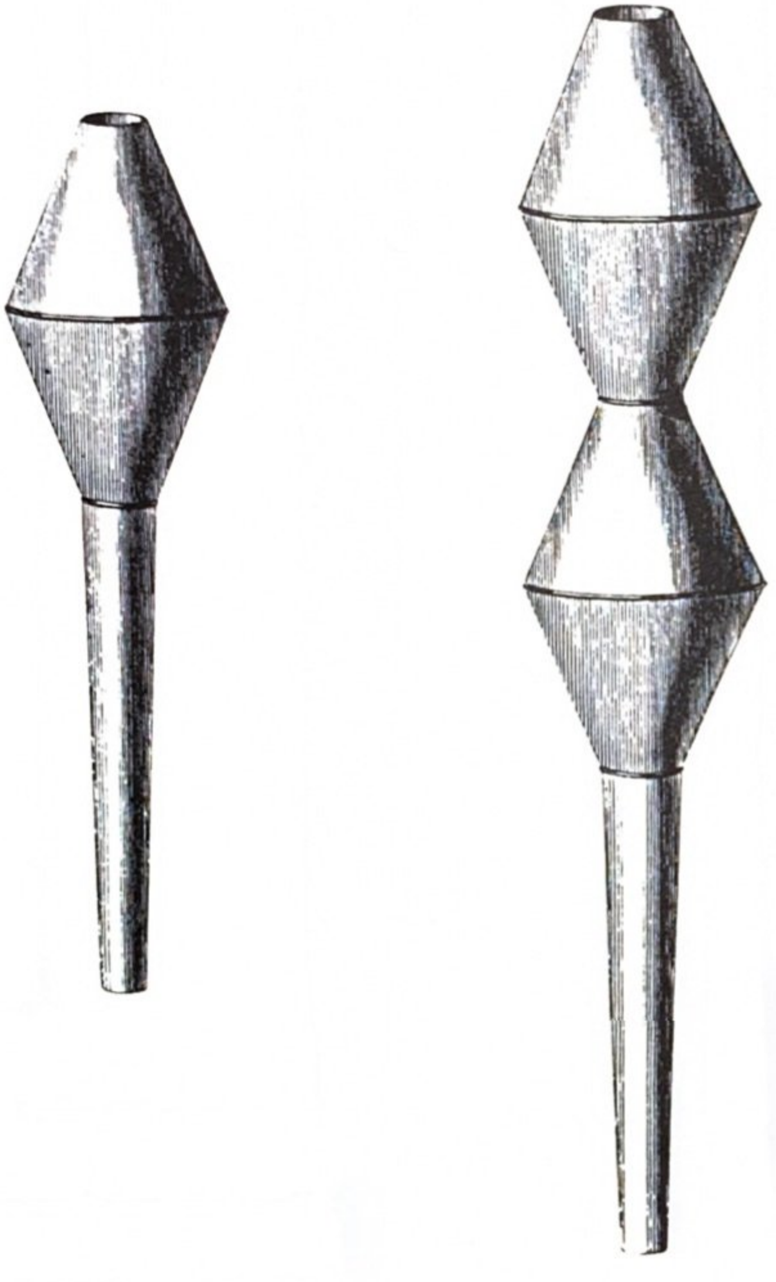
58. Dulzian or musette; cromorne.



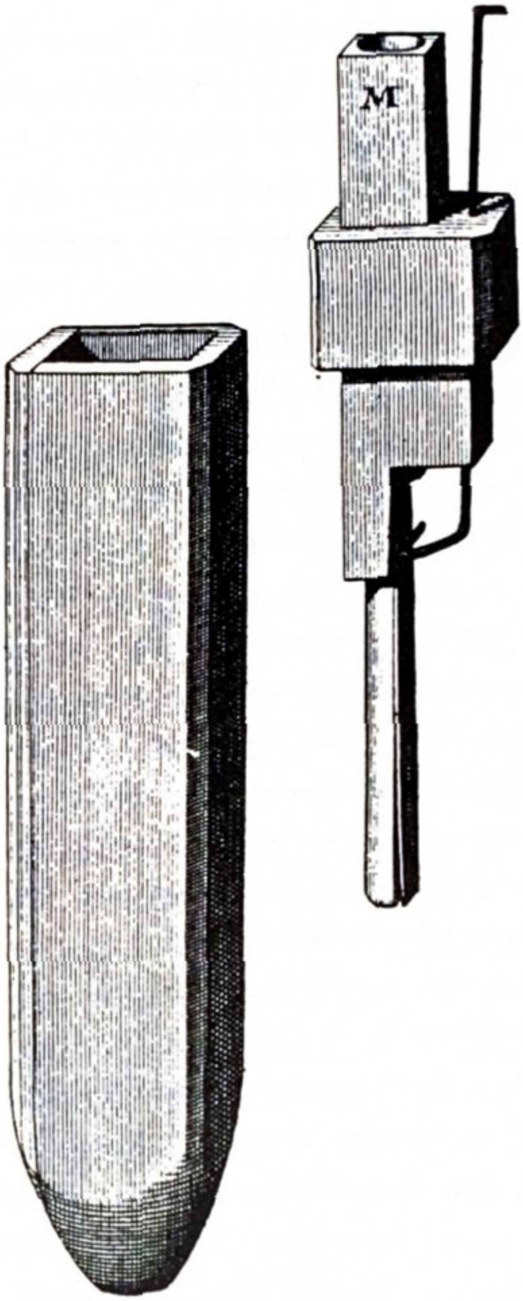
59. Hautbois; voix humaine; regal.

some dulzians and regals. The use of wood for the block of any type of reed is relatively rare, although in the eighteenth century and earlier such use was more common than today. Fig. 61 shows a typical wood block and boot of a pedal stop of large scale.

The voicing of reeds is not difficult to describe, but the techniques are not easy to acquire. Curving a reed tongue



60. Left: basson resonator; right: regal resonator.



61. Pedal bombarde with wooden block and boot.

is somewhat like playing a complicated scale passage: if the player has spent years working on technique and is in practice, it sounds easy, but if an amateur plays the same music, it sounds deplorable. Yet in a sense the task is really a simple one: to give a smooth curve to a thin strip of spring brass by burnishing it. The curve may be described mathematically as a parabolic section. The tongue must be shaped so that when it begins to vibrate under the force of the wind it enters a resonant mode in which once each cycle it lies flat along the surface of the shallot, closing the opening and momentarily stopping the flow of air. At the apogee of its cycle the tongue is in its state of least contact with the shallot. As it moves toward the closed state the point of contact rolls smoothly toward the tip, remaining in contact at all points.

The voicer first prepares the shallots by grinding and polishing their faces so that they are flat and true. They are then filed flat with a special file which is flat on its working surfaces, of medium to coarse cut, and at least 1 cm. thick. In shaping a shallot it is important not to raise either end off the grinding surface, for to do so will impart a curve to its face, which then must be made flat again. The shallot is held down by as many fingers as will fit along its length while it is scrubbed back and forth longitudinally on the file until the surface exhibits a uniform patina. After it is filed, the shallot is then ground on successively finer grits of emery. The various grits of emery cloth are glued to wood slabs that have been planed flat. The final scrubbing is on crocus cloth. When the shallot is perfectly smooth and flat, it is polished with the flat side of a burnisher. Finally, the shallot is tested for flatness by examining it on a surface that is known to be optically flat. No light should be visible between the shallot and the gauge.

In addition to being made of brass, shallots may also be made of wood. Whether made of wood or brass, they may be faced with lead, pipe metal, or leather, depending on the effect that is desired from the stop. A shallot with a brass face develops a somewhat clangorous tone that may not be appropriate to the style of the organ. During the time of Arp Schnitger, it was common to face the shallots of the pedal posaune with a thin layer of hard leather. This treatment imparts a more decorous sonority to the timbre than that which is obtained with brass alone. Somewhat the same effect is obtained by using tin or lead; the mellowing effect is not as great as that of leather, but the metal lasts longer.

To make the tongue, a piece of brass is cut and shaped to the outline of the shallot. After selecting the brass, the outline of the tongue must be aligned on the brass sheet so that its grain runs parallel to the length of the tongue. If an industrial shear press is available, oversize rectangles are cut for each tongue and set in holes in a tray made to keep the shallot, tongue, and wedge of each note separate from its neighbors; this also keeps them in sequence. If the brass is cut on a small press or with shears, the bites of each cut must be small so that the metal is not warped. The final shape is made by scribing the blank to the outline of the shallot, after which the excess metal is cut or ground away. Thicker metal can be shaped by clamping the blank in a smooth vise in order that a small plane may be used to trim it to width. Some voicers will hammer the metal to anneal it before it is treated further.

The blank tongue is then filed or polished on emery cloth (Pl. XIIa) until it no longer shows scratch marks. The file used must be flat and of a fine double cut. After filing, the tongues are polished with a fine grit of emery. They are held against the surface of the emery board with a sanding block 2 cm. wide, the surface of which is coated with a nonskid material to keep the tongue from slipping. When the scratch pattern of a grit is uniform on both sides of the blank, it is taken to the next finer grit, ending with crocus cloth. If the edges have not previously been smoothed, they are filed or ground square. The polished blank is then smoothed on both sides with the flat side of a burnisher. From this point the surface of the tongue is never touched by the voicer's hands unless it is immediately afterwards wiped clean with a lint-free cloth or fold of paper.

The tongue blank is given its curve by burnishing it against a curving block (Pl. XIIb) made of metal or dense hardwood. The curving block may be flat for its whole length or raised at either or both ends into a parabolic curve. It should be about 40 cm. long and 5 cm. wide and thick enough to resist any applied force by the burnishing process without deforming. A convenient means of fastening the block to a workbench is needed. There should be at least one curving block that has a clamp at one end to hold a large tongue in place. Otherwise the voicer holds the tongue in place by pressing its upper end to the block with the thumb of one hand.

The tongue is curved by applying gradually increasing pressure with the curved surface of the burnisher, beginning with the back of the tongue and moving past its tip and allowing the burnisher to ride off the brass and onto the curving block. The burnisher is kept at right angles to the tongue and held so that pressure is exerted evenly across its width. The amount of force exerted depends on the thickness and hardness of the brass.

The newly curved tongue must be handled with extreme care so that it does not become damaged. To place it in the block, the pipe is laid horizontally and the tongue slipped into its place; it is held firmly with the fingers of one hand so that it does not slip out of alignment while the wedge is pushed into place with the other. The wedge is seated (Pl. XIIIa) by driving it in with a small hammer or by pushing it in with the tip of a screwdriver or burnisher. This must be done without touching the tongue, and the tongue must be held tightly in place so that the wedge, in being seated, does not drag the tongue too deeply into the block. To be removed, the wedge is grasped with parallel-jaw pliers (Pl. XIIIb) and pried loose from its socket in the block. The voicer must avoid damaging the tongue while the wedge is being extracted.

To seat the tuning wire, it is pulled down as far as it will go, turned into alignment with the tongue, and slid into position near where the note would be in tune. The tuning wire is pulled back (Pl. XIVa) so that it does not bear fully against the tongue while the wire is put in position. If the wire has been pulled out past the end of the shallot, the voicer must without fail guard against catching it between the tongue and the shallot.

If the tongue is not removed from the pipe to be curved but instead is burnished against the shallot, the shallot must be securely supported so that it is neither bent nor loosened in the block. Shallots that are not closed on their back end are especially susceptible to being deformed. If the shallot becomes warped, it must be ground flat again.

While it is being shaped, the tongue should be examined at intervals until the preliminary curve is judged correct. A finished tongue should resemble the one illustrated in fig. 53. To examine the curve, the tongue is held at its back end against a flat surface. If the curve seems correct with the tongue relaxed, the tip is then pressed down to the block so that its whole length is against the gauge. If no light shows between the tongue and the block, the curve is probably correct, and the note is ready to be tested on the wind.

A reed pipe must *never* be made to sound by blowing one's breath through it; the moisture that condenses on the tongue and shallot is corrosive.

Certain reeds have been successfully voiced by a technique known as "draw filing" which imparts the voicing curve to the shallot instead of the tongue. The tongue is left flat, and the shallot is filed until its profile is the same as that of the tongue if it were curved. It is perhaps more difficult to shape a shallot than a tongue, but the curve, once made correctly, never changes. Some reeds made by the Aeolian-Skinner Organ Company were voiced in this way during the 1950's.

The thickness of the tongue determines how the note will speak. If the pipe is put in tune—and if the tone is dull and the attack somewhat slow—the tongue is too thick. If the note cannot be put in tune because the tuning wire strikes the wedge, the tongue is too thick or the pipe is too short. If the tone is thin and harsh or if it rattles in an uncontrolled manner, the tongue is too thin. The voicer must distinguish between the thickness of the metal and the curvature of the tongue, and he must determine that the curve is normal before changing to a different thickness. A tongue of the correct thickness will be slow of speech if the curve is regular but too great; it will buzz without speaking its resonant note if the curve is not sufficient.

If the pipes are left dead length—that is, without a regulating or tuning roll—they must be trimmed to length after the final voicing. The voicing must be examined carefully after cutting so that the tone does not suffer. A pipe that is too long will tend to fly off speech, sounding a harmonic of its pitch. If it is too short, the tone will be blatant and unsteady. A pipe will leave its note and speak on a harmonic pitch if the top of it is covered with the hand. If the note does not return to its own pitch when the hand is removed, it is too long and should be trimmed slightly. Pipes with tuning or regulating slots cut in their sides near the top allow some leeway in the cutting to length.

A tongue should not be curved back and forth more than two or three times in voicing it to its curve. A tongue that is over-burnished loses its temper and must be replaced. The burnishing rearranges the internal crystalline structure of the brass only by the amount necessary to bring it to the desired curve, but each burnishing reduces the ability of the metal to remain sufficiently elastic to keep its shape. It will eventually bend from the pressure of the tuning wire and from its own movement while being played.

The tongue must be curved so that it will lie flat on the shallot and must bear equally against it on both sides without any tendency to twist. If a warped tongue cannot be corrected with one or two passes of the burnisher, it must be discarded.

Some voicers prefer to burnish the tongue by laying the brass on the curved end of a parabolic curving block. The tongue is stroked back and forth with the tip of the burnishing tool until it begins to assume the shape of the block. The brass strip may also be laid on a flat surface and burnished with the back of a knife; this technique is described by Dom Bédos and was the style of voicing in the French Canadian firm of Casavant Frères.

The basic curve is made by using either of the two methods described until the pipe speaks its basic note, but refinements are commonly made without removing the tongue from the block. To make the curve lie flatter against the shallot, the boot is taken off and the shallot is supported by the edge of the workbench as the burnisher is passed along the tongue from base to tip, beginning at the wedge. The spring is slipped aside for this operation. In cases in which the curve is insufficient, the burnisher, if thin enough, or a knife blade is slid between the tongue and shallot (Pl. XIVb) but not forced under the wedge. The voicer's thumb presses lightly on the tongue as the tool is drawn forward, angled so that the tip of the tongue is raised slightly. This operation requires great care since it is easy to kink a thin tongue.

The use of higher wind pressures requires that a sharper curve be given to the tip of the tongue. The use of thicker metal may require weighting the tip of the tongue slightly so that the tone will not be unduly blatant. If a tongue needs a small amount of extra curve at the tip beyond that which can be imparted with the burnisher and block alone, a thin slice of dense felt is placed between the tip of the tongue and the burnishing block. The tongue is rubbed with the burnisher just back of the felt so that the metal is curved only in that area near the tip.

Reed stops are tuned by moving the spring up or down (Pl. XVa) to control the vibrating length of the tongue or by shading the top of the resonator with a tuning roll or sleeve. The pitch of a reed that is "close-voiced"—that is, having a small opening in the face of the shallot—is more affected by shading than by moving the tuning wire, which should not be moved unless the strength of the note needs to be changed. There is no rigid rule about this: pipes of any style may have to be tuned by making adjustments both to the spring and to the top. The need is determined by the sound; if moving the spring puts the timbre out of regulation as the note comes in tune, then the regulation must be restored by compensating with the opposing motion of the roll at the top.

A reed stop will not stay in tune unless it is correctly racked. At those places where the boot or resonator touches the rack there should be a thin layer of dense felt to absorb the vibrations that could cause the rack board to rattle. If the pipes are crowded together, those that touch should be felted at the point of contact. Regulating rolls that are loose should be felted for the same reason. If the toe of a pipe is off the wind so that air leaks around it, the tone will be harsh, rasping, and unsteady. Re-seating the pipe is done by bending so that the toe rests firmly in the countersink with only the pipe's own weight holding it down. If the rack board hole is too small, it must be enlarged so that the pipe is not forced up out of its seat.

The pipes should be turned so that the tuner can reach each wire without touching any other wire while tuning, and the pipes must not be so crowded that a tuning bar cannot be held horizontally in tuning all notes. Sometimes this calls for what appears to be random untidiness in the orienting of the pipes.

The surfaces of the shallot and tongue that meet must be clean for them to generate the proper timbre. Anything that interferes with the contact between shallot and tongue causes the pipe to react as if the curve were flawed. In removing a reed pipe from its rack to be cleaned, great care must be taken to prevent anything from falling into the windchest. If the inside of the resonator is dusty, it should be wiped clean before the pipe is replaced. Thorough cleaning may require the disassembly of the pipe and washing or scrubbing the inside of the resonator. This may be done with a bottle brush, if necessary, but ordinarily a soft rag will do the job. The tongue should be removed for its protection and the tongue and shallot polished before being put back in the pipe.

In moving the tuning wire, the tuning tool should be balanced lightly in the fingers (not gripped like a club) and swung so that the tool strikes the wire squarely up or down, not with any great force (Pl. XVa). The control must be exquisite. If the wire does not settle neatly into its new position, it should be given a slight lateral tap just above the block. If the pitch changes, the voicer should gently bring the note back to pitch and tap it sideways once more. The note should now hold pitch.

A voiced pipe that sounds unlike its neighbors is probably dirty. Insects, bats, and small birds occasionally fall into pipes where they are trapped by the smooth confining walls and cannot crawl or fly out. Their removal is frequently unpleasant but essential. Airborne dust and trash fall into pipes, and chips of wood or dirt may come up through the wind system. A dirty pipe must be cleaned before it is tuned, and then its voicing and regulation should be checked.

There are two ways to clean a reed pipe. The simpler method is to pass a sheet of lint-free paper between the tongue and shallot. The motor of the pipe is removed and the tuning wire slipped aside. To relieve the pressure of the tuning wire against the shallot and tongue, the end of the wire is pulled away so that it no longer touches the tongue (Pl. XIVa). Then the tuning wire is turned aside so that it may be pulled up against the block, where it is out of the way. The horizontal end of the tuning wire must not scrape against the tongue since this will damage or even destroy the tongue. With the pipe held upside down so that nothing inside the resonator falls into the shallot, the mating surfaces are cleaned by slipping a clean piece of lint-free paper (e.g., a bank note) between the shallot and tongue (Pl. XVb). The paper is slid up until it will go no further without being forced, the tongue is held lightly against the shallot, and the paper is withdrawn. This treatment will remove most troublesome particles. If the problem remains, the shallot and tongue must be removed and polished and the resonator scrubbed. Reeds must be handled gently. It is easy to knock trash into a pipe, and it is easy to unseat the tuning wire from the tongue in routine tuning. Once the tongue is correctly curved and the wire seated against it without stress and in alignment, the tuning should be reasonably stable, susceptible of course to a change of temperature.

Coda

Fine voicing is essential to the building of a fine organ. It seems appropriate to summarize this discussion of voicing with an examination of the organ from several different perspectives: in relationship to others of its kind, in relationship to its environment, and according to its general and specialized uses as a musical instrument. These four topics may be stated as engineering, architecture, music, and liturgy. An organ of truly high quality must be well voiced, to be sure, but it must also excel in other ways.

There is little disagreement among better organ builders about the nature of organ construction with regard to the quality of the materials from which are fashioned the wind system and the action that controls the delivery of the wind to the pipes. While many worthwhile innovations have been advanced in electricity, plastics, and metallurgy in the past hundred years, the basic key channel chest and tracker action have not been supplanted by anything superior.

During the Romantic era the style of organs underwent change from the instruments of the time of Bach—change analogous to that which affected the instruments of the orchestra. The changes followed the prevailing trends in the development of music, which tended to be harmonically oriented rather than linear or contrapuntal. Upperwork, essential for the creation of contrasting lines and textures, was augmented and in part supplanted by color stops of eight-foot pitch. The proliferation of these stops of lower pitch increased the wind demands, which in turn made it more difficult to press down the keys. Different builders approached this new problem in different ways, but eventually all of them turned to some kind of power-assisted action. One of the first innovations in this regard was the dividing of pallets so that the downward movement of the key engaged two pallets successively instead of one larger one. The touch was thus made lighter in the same way that staggering the plucking points of a large harpsichord keeps the touch light even when playing several choirs of strings. But with the organ, the improvement is minimal.

Audsley provides historical information about subsequent developments (*The Art of Organ-Building*, II, 244–45). The next move away from the simple direct linkage was the invention in 1835 of a pneumatic assist by the Edinburgh builder David Hamilton, who also invented the device in use today called the pneumatic pouch. C. S. Barker of Bath and Henry Willis modified Hamilton's original mechanism into what became known as the Barker lever. Their version was first used in the organ by Cavaillé-Coll in St. Denis Abbey, Paris. Subsequently electrical devices were employed by various builders to open the first, or primary, valve of such systems, and some makers developed actions that use no pneumatic intermediaries but instead have only electromagnets that do everything.

Each new method of controlling the opening of pipe valves removed the organist one step further away from direct control over the phrasing of the music. The faults and virtues of these systems versus the older direct mechanical linkage continues, and will not be settled in these pages.

But as far as the voicing of pipes is concerned, there is general agreement that pipes can be voiced much more easily on the relatively low pressures used in mechanical action organs and especially on the key channel chests used in them. For the reasons mentioned in the chapter on voicing, a principal chorus cannot be voiced on other than a key channel chest without somewhat degrading the timbre.

It is interesting to note that there are numbers of notable organs built during the nineteenth century of considerable size and complexity but relatively few examples from the early part of the twentieth century. Those American organs of note are quite few, being recognized for reasons of sheer size, the possession of some unusual feature, or a remarkable single stop. The key channel chest and tracker action died out in North America during the 1920's, not to re-appear until after World War II.

It was not the Romantic movement *per se* that led to these changes but the post-Romantic development at the turn of the century of the unit organ by Robert Hope-Jones. His influence on English and American organ building led directly to the development of the motion picture theater organ, which was so widely imitated in the years before World War II that conventional organ building almost died out. The typical organs built for church use were only slightly more refined than theater organs, and many of them were as highly duplexed and unified. Only the names of the stops were distinctly different between the two genres, but even these were sometimes found to be taken from the Hope-Jones model.

The tonal changes and developments of the Romantic period were quite pleasing in their way and represented a change in character or emphasis while not losing the essential musical nature of the organ. With the unit organ and its descendants of the post-Romantic era, however, the organ was quickly degraded into a sound effects machine, a large version of the eighteenth and nineteenth century mechanical organs and hurdy-gurdies but with even less refinement. It is the degradation of tone exemplified by these instruments that has colored our perception of the Romantic period, which was not so inferior after all.

The organ of the early twentieth century could not work on the accustomed pressures for voicing pipes, and the raising of pressures to accommodate the action forced voicers to compensate with such measures as excessively deep nicking, excessive slotting of pipes, and the use of large bars or similar devices in front of the mouths of pipes just to enable them to speak. The novelty of these contraptions diverted the attention of organists and builders alike, and what we would now regard as organs of quality were not built for a time except on the continent of Europe where not everyone was as captivated by gadgetry as we and the English were.

Eventually the pendulum of taste swung back after numbers of American organ students went to Europe to study organ on Fulbright grants and other scholarships where they found that the great teachers taught on great organs for the most part. Those organs were very different from our typical ones, and these returning musicians pressed our native builders to return to the older ways of doing things. There was also the voice of the deutsche Orgelbewegung speaking all this time—*sotto voce*, perhaps, but insistently—and it was not long before the historians and the returning organists brought about a general return to traditional organ building methods.

The simple fact of it was that organ builders were forced to recognize the inadequacy of various types of pouch or solenoid chests as suitable foundations for first-class pipe work. By 1990 at least two major organ building firms had re-established the slider and pallet windchest as their standard action of quality. During the preceding three decades literally scores of smaller firms arose that build nothing but mechanical action organs, and the larger firms that have resisted returning to the older form of action have lost their pre-eminence in the field.

The mechanical link from pallet to key is generally held to be the best way to connect the player's fingers to the pipes. Many organs of fine quality are built, however, which lack this feature, even though their pipes stand on key channel chests. The effects of direct linkage are considerably more difficult for the listener (who is not also the player) to detect since a fine organist can still phrase elegantly if the keyboard has a clean touch and if the electric action of the key channel chest is responsive. It would not be fair to say that no great organ can be built this way; the judgment is a subjective one.

Some maintain that the wind in a reservoir is not sufficiently tranquil if it is stirred up by an electric fan, while others claim that any fault introduced by the use of electric blowers is more than offset by the convenience of not having to find a person to raise the wind every time the organ is played. There are some features of an organ which have little or nothing to do with the quality and character of the sound, but these matters are not easy to prove conclusively. The organ always was a creature dependent on technology, even of the crudest sort, as the hydraulus certainly was. Every alteration in the name of improvement was resisted, up until today, when we still debate the merits of returning to mechanical key action since it would mean giving up the freedom of placing the keyboards wherever we choose.

As the organ developed in richness and complexity, culminating in the work of Arp Schnitger in the early eighteenth century, certain general principles about organs began to be evident. There is no theoretical limit to the size of any single organ, but certain relationships emerged regarding the size and placement of an organ and the room in which it stood. Without being a law of physics, the rule of thumb which allows about twenty-five seats in a church per rank of pipes in the organ will allow, in a favorable acoustical environment, the calculation of an organ of about the right size for that room. The exceptions to the rule are legion, of course, but not germane to the topic under discussion here.

It is apparent that an organ suffers if it is not placed in the open in the room in which it is to be heard and if the room does not have reflective surfaces. The best sort of room for the organ is something like the best concert hall, which is shaped like a shoe-box, having parallel sides and simple relationships in its proportions of length, height, and width. In addition, the organ is most favorably placed if it is oriented to the long axis of the room and speaks from an elevated location.

Walls that are smooth and flat will reflect all frequencies evenly, but sometimes this is too much for clarity. Textured surfaces are better, and the absence of echoes is essential. The organ seems to sound best in those rooms that favor the sounds of good choral groups and small string ensembles, even if the acoustics are dry enough to permit speech to be intelligible. The use of carpet and amplification systems, however, normally degrades musical sounds, especially the organ.

An organ which is correctly made for its liturgical and accompanimental purposes can support abstract composed music. The organ is peculiarly well suited to the performance of counterpoint from complex fugues, the spare lines of a trio, or the rich texture of a canon.

The question of being able to generate better sounds in an organ does not particularly reside in finding different ways to voice or re-voice a pipe but in re-educating our ears to the point that the sounds made by the pipes alone can be separated from the acoustic ambience in which they are placed. These isolated pipe sounds must then be analyzed for their own sakes and evaluated for musical quality. The problem is similar to analyzing and evaluating the sound of the human voice in a singer—or the sound of a violin or a woodwind. Organs unquestionably sound better in rooms with four or five seconds of reverberation and with even dispersion of all frequencies, but it is extremely difficult to isolate the sounds that reach the ear directly as they come from the pipes as opposed to the sounds that reach the ears after they have been qualified by the room into which the organ speaks. One only makes a social comment, not a musical judgment, by remarking that a certain organ is exceptionally fine if it is judged in such a context.

The ear is easily fooled; this common saying should be sufficiently indicative of the fact that the interpretive sense rather than the ear must be educated. Good pipe work in an organ can be detected fairly easily once the pipe sounds are perceived separately from the room. Good pipe work engages the interest of the listener in such a way that one becomes involved with the entirety of the music rather than merely with the separateness or unique qualities of the pipe sounds. The organ behaves in the same way as any well-blended orchestra or chorus in that it should not sound as if it were a collection of separate players or singers; instead, it should sound as an ensemble, the timbre and dynamics of which are made to change under the control of the organist.

Good pipe work is articulate; as with speech, there are vowels and consonants so that phrasing is distinctly heard. The beginning and end sounds of pipe speech, while they should not call attention to the matter, render musical lines cleanly. Voice leading is distinct, and the balance of the parts is correct. Good pipe work is neither blatant nor muffled; it may be loud or soft, but it is not exaggeratedly so. In the case of orchestral voices, the best pianissimo sounds are those made from a small number of instruments each playing at a moderate dynamic level, not by the whole orchestra playing as softly as possible—a practice which only makes an indistinct, enervated sigh. The same principle applies to the organ. Further, an organ fortissimo is produced by drawing a few brilliant reeds and mixtures with a handful of foundation stops which can produce, as G. Donald Harrison once put it, "a sound of fiery brilliance." But such an ensemble is not forced, nor is it uncomfortable to listen to.

Good pipe work has the characteristic of presence, of immediacy and completeness, sounding as if it is nearby and meant to be heard from close at hand. If the pipe work is distant from the listener—or from the player—it cannot be effective in its ordinary use.

The surest and most outspoken analysts of organ sounds are orchestral musicians who are part of an ensemble which includes the organ. If they are playing in dialogue with the organ or if they are being accompanied by the organ, they expect the organ to behave like any other instrument in their group. If the pipes are distant or dull or inarticulate or too loud or too soft, they are quick to recognize the fault and will call for a change of registration until the organ sound assumes its proper perspective in the ensemble. Without asking everyone who wishes to judge organ sound to become proficient on some other instrument, the next best way to approach the task is to learn how instrumentalists and singers listen to and evaluate their own tone production, and then to apply those same techniques to the judging of organ sound.

One starts by listening to one single aspect of one single tone to the exclusion of everything else until that particular characteristic can be isolated and evaluated. When a string player begins to learn how to play, the first task, beyond having a violin or cello that is in tune, is to learn how to drag the bow across a single string so that a steady tone is heard. It sounds very simple, but that first step is a very big one indeed. Generally by the time the beginner can make one steady musical note he or she has spent enough time with the instrument to do many other things than merely to bow a single open string.

Such experimentation with an instrument sorts out in a fairly short time those who can be trained to listen from those who cannot, but then those who cannot or who will not listen generally do not become musicians. But experimenting with an organ guarantees nothing of the sort in learning how to listen because the organ by its nature does everything for the player except to hit the right notes. It is an instrument of such complexity that it intimidates most players on first acquaintance and diverts the rest into an exploration of the amusing and unexpected things that the mechanism can do; thus the tonal analysis is easily overlooked. Perhaps anyone interested in the organ, whether as a player, a tuner, or a voicer, should be made to learn how to register and play a tonally complete instrument that has no labels on any of its controls.

The organ began as a curiosity among simple noise-making machines, and it might have remained just that without the influence of the Church. During the later Middle Ages the organ was discovered to possess the necessary characteristics to assist singers with chant of one sort or another and also the ability ideally to sustain the drone of organum. The great number of early illustrations depicting a small portativ or positiv in a liturgical context provides overwhelming if indirect evidence of this common use of organs. Some 290 examples are catalogued by one researcher alone (see Kimberly Marshall, *Iconographical Evidence for the Late Medieval Organ in French, Flemish, and English Manuscripts* [New York: Garland, 1989], 2 vols.).

The Protestant Reformation changed more than the nature of worship. It also brought about the changes in liturgy necessary for the encouragement in worship of the use of composed music unrelated to vocal accompaniment. The north of Germany saw the rise of many notable Church composers whose music still forms the heart of organ literature. Nevertheless, the principal task of the organ remained the accompaniment of voices: the community of religious in Divine Office, the congregation in hymns, and choirs and soloists in composed music used during worship.

There is no single type of liturgical organ being built today. Liturgy is quite diversified in late twentieth-century America, and in many of its forms it is not compatible with the use of the organ. Conversely there are other liturgical practices in which the organ is used as if it were in a concert hall. Whatever its nature, if liturgical use demands an organ there is a builder who will meet that demand. While tastes and customs vary, within each style of organ that is built for church use there is a body of composed or improvisational literature to be played on it; concomitantly the organ that is suited to the liturgical use is also suited to the accompanying literature.

The larger the organ the closer it comes to being all things to all people. This is neither good nor bad, but a large organ that can be used to play all styles of music will not sound authentic, perhaps not even characteristic, of smaller instruments that are built in the idiom of a particular tonal school. This is so for the simple reason that very large organs cannot be built within the accepted limits of casework size and disposition. Consequently while the stop list and voicing style may encompass all that there is to be had, the very size and separateness of the divisions do not work to produce the expected kind of sound. These monster organs have a character of their own, and, though they may differ in tonal style, they sound more like one another than like smaller instruments of any tonal school.

For technical reasons discussed elsewhere these very large organs are almost always controlled by an action other than simple direct trackers—a characteristic which removes them yet one more step away from the ranks of the greatest organs. However, they serve their purpose, and the better their pipes are voiced the better they sound.

It may be instructive to analyze a well-voiced organ which fulfills its expected functions in all of its liturgical uses while yet illustrating some limits that are enforced by external circumstances. In 1990 the author rebuilt an organ in St. Norbert Church in Roxbury, Wisconsin, that contained the remnants of an 1893 tracker (Pl. XVI). It is in a stone church built in modified Romanesque style having plaster walls and ceiling and a wood floor. The building is 131 feet long, 38 feet high, and 39 feet wide with two shallow transepts and a spacious rear balcony for the organ and choir. The chancel and aisles are carpeted, but the open, uncluttered nature of the room compensates. The reverberation period is about four seconds. No amplification is necessary for singers although the chancel carpeting requires its use for speakers who do not project their voices well. The sound of the organ is evenly dispersed throughout the room and may be heard to bloom at the chancel steps.

The Great division is entirely new and consists of seven stops encased on an electric slider chest. The Swell is both new and old, containing some stops of the original organ, and is on two pitman chests. The Pedal has two new stops and two old ones on electrically-operated unit pouch and solenoid chests. The whole is contained within the original façade. Whether the organ is considered new, restored, or rebuilt is a matter of semantics, but it is in the consideration of whether to keep or replace pipes and windchests, what and how to revoice pipes, and how to scale and voice the new pipes that may provide illumination.

It is beside the point to justify rebuilding this organ rather than replacing it outright; the work that was done was within the financial limits imposed by the parish. Present plans call for the eventual replacement of the Swell and Pedal chests with new ones of slider and pallet design. It would be ideal to restore tracker action to this organ, but that is not in the plan.

In addition to the changes already mentioned, the console and blower were replaced. The wind is supplied by a small modern blower delivering 125 mm. pressure to two reservoirs that reduce the wind to 70 mm. One reservoir supplies the Great with wind that is further reduced to 62 mm. by a schwimmer valve.

The reservoirs control the wind pressure by weights alone. The floating plate of the schwimmer is somewhat flexible. The combination of weights alone on the reservoirs and the flexible schwimmer plate impart a deliberate elasticity to the wind, but there is no evidence of instability or shakiness. As Fritz Noack expresses it, the wind nods gently to acknowledge the onset of pipe speech.

The stops of the Great are:

Diapason 8′
Chimney Flute 4′
Octave 4′
Spire Flute 4′
Recorder 2′
Mixture IV
Trumpet 8′

A basic scale of 142 mm. (NM – 3) was chosen for the Diapason, halving on the seventeenth note and with a 2/9 mouth ratio. The Octave was made two notes smaller and with a 1/4 mouth ratio. The mixture is two notes smaller than the Octave, begins at the 1-1/3′ pitch, and has 1/4 mouth unisons and 2/9 mouth quints. The first break is at F#°, and the remainder of the stop is evenly divided among the remaining breaks. The eight-foot pitch is introduced in the top octave.

The Chimney Flute scale is 110 mm. with a 2/9 mouth and no chimneys below c′. The Spire Flute is 70 mm. at CC with a 1/5 mouth and tapered from the mid-point in a 1:2 ratio. The Recorder is small, with a taper that graduates from 1/2 to cylindrical over the first two octaves and a mouth width that graduates from 1/5 to 1/4 over the same range. Thus it becomes a principal at middle c. Its halving ratio is on the seventeenth note. The Trumpet is 125 mm. at CC, has modified early French style shallots, and is voiced with unweighted tongues throughout. The first twelve Diapason pipes are made of zinc, but the remainder of the principal chorus pipes are 70% tin. The Chimney Flute and Spire Flute are 40% tin and the Recorder and Trumpet 50% tin.

The Swell stop list is:

Stopped Diapason 8′
Salicional 8′
Voix Céleste 8′
Flûte Ouverte 4′
Nazard 2-2/3′
Principal 2′
Tierce 1-3/5′

The Stopped Diapason, Salicional, Voix Céleste, Flûte Ouverte, and Nazard are from the original organ. The Principal and Tierce are relatively new pipes salvaged from another organ.

The Pedal division contains four stops:

Bourdon 16′
Open Bass 8′
Choralbass 4′
Posaune 16′

The Bourdon, Open Bass, and part of the Choralbass are from the original pipes, and the Posaune and upper part of the Choralbass are new.

The original Bourdon was replaced by the Swell manual double (which had earlier been removed and stored) in order to obtain pipes of a more suitable scale. The Octave Bass was made by using the original NM scale Open Diapason, the lower part of which is in the façade. The lowest five Choralbass pipes are from the original façade, and the remainder of it of new 70% tin pipes, also NM scale.

The Posaune is a new Schnitger-style stop with wood resonators of full length and 170 mm. scale and brass shallots faced with lead.

There are enough old and new materials in this organ so that it displays many of the typical faults as well as the virtues of characteristic American instruments that have been upgraded. The original parts of it were built by the Schaefer firm of Slinger, Wisconsin, near Milwaukee. The present façade is virtually unchanged from the original configuration. In 1949 the mechanical action windchests were removed and the pipes were re-scaled and augmented with several additional ranks, the whole being placed on supply-house electropneumatic chests of questionable efficiency but typical of their time. The revoicing consisted chiefly in deepening the nicking and raising of cut-ups. Everything except the Pedal Bourdon was enclosed in a paperboard box with shutters all across the front, immediately behind the case pipes, most of which were disconnected.

Some years ago one of the chests of the Swell division failed and was replaced with a new one of similar design. At the same time the enclosing box was greatly reduced in size so that only the Swell remained under expression, and some of the nicking of the pipes was rubbed out.

When the present renovation of the organ was discussed the parish authorities wished to have the instrument re-configured so that it could support a versatile music program of high quality. They felt that there was sufficient material in the existing organ to retain, although in retrospect it might not seem that there was.

The console, blower, electrical system, and most of the Great division were discarded. Only the pipes of the Diapason that were in the façade were retained. The original Bourdon of the Pedal was removed, as were the zinc basses of the remaining pipes. The cardboard enclosure was not disturbed, since it will be discarded when the chests of the Swell are replaced with a single slider and pallet chest. At that time three more stops will be added and the whole enclosed in a box made of solid wood. Since a slider chest is considerably more compact than a pneumatic chest that contains the same number of pipes, enough space will be made available to install a new chest for the Pedal in order to increase its number of stops.

There was nothing worthy of redemption in the Great stops: Open Diapason, Melodia, Dulciana, and Octave, all heavily nicked. The chorus of the main division is the heart of any organ, and the chief effort of the renovation went into making an ensemble worthy of the room. Therefore everything was designed and built to attain that end.

Since there was limited space available for Pedal stops, the old pipes of the façade were made to play, and the addition of one slender chest enabled an arrangement to be made so that there were three independent flue stops. The location of the 1949 chest that once held a second bourdon (the old Swell Lieblich Gedackt) made it suitable for a large reed stop but not for upperwork. The obvious choice was a Posaune.

Many organ builders have faced similar choices in picking through the pieces of an old organ to save this and to discard that. There is no clear boundary between what to keep and what to throw away. Each choice needs to be made on its own merits.

In the revoicing of old pipes the nicking of the wood stops is filled in with sealing wax or stick shellac (both made of the same basic substance). The caps of the pipes are removed and the nicked surfaces cleaned thoroughly to remove soot. The wood is heated with a large soldering iron kept at a temperature low enough not to scorch the wood or the shellac. The shellac is melted onto the wood, and the excess is scraped off before the material hardens. When the pipes have cooled and the shellac has hardened, the surfaces are squared up with a flat file and the edges carefully dressed to prevent chipping. Flues that are large may be closed up slightly with a thin layer of shellac, but if the gap is excessive it may be better to plane down the block or cap, whichever seems practical to do. If there is a deep well in the block behind the flue it should be filled in, and if the cut-up is high it may be set lower with the gluing in of small pieces of wood. Neither of these operations is easy to accomplish in a neat and practical manner. The configuration of these areas of the pipe will enable the voicer to decide whether to salvage the stop or not.

Since the original case pipes of the Diapason were not revoiced in 1949 there was no need to remove excessive nicking. Squaring and cleaning of the flues was all that was necessary to make them sound as satisfactory as zinc pipes can be made to sound.

The two string stops presented the most difficulty in revoicing. The low octave of the Salicional was not adequate and was replaced with capped metal pipes that were made for the bass of a Quintadena. The slots of the open pipes were cut open, the bars removed, and the nicking rubbed from below the languid with a steel rod.

The upperwork presented a different set of problems. The Nazard had been the Twelfth in the original organ; it was of tin and not heavily nicked. Almost all pipes were salvaged. Of the Principal and Tierce, only the lower quarter of the pipes were usable. Suitable unused classic style pipes that matched the scale were put together to make up two coherent stops.

The pressure of the organ had been 120 mm. before the renovation. Since the action worked as well on 70 mm. as it did on 120 mm., it was set at the lower pressure. It was this change which made possible the salvage of the old pipes. The reduction of pressure resulted not so much in a lessening of volume as a clearing up of pipe speech. Pipes which before had sounded harsh, hooty, and dull would sound much less so, and what brightness they had was more apparent. The nicking of the two wood stops had been filled in earlier, and they had been regulated to play on the higher pressure. Neither stop needed more than the evening out of a few notes here and there for them to become what was desired on the lower pressure. The only operation done to all of them was to countersink the toe holes uniformly.

All of the metal pipes were made open toe to the degree that in every instance the toe hole was larger than the chest boring so that there was no impediment to the flow of wind into the foot. The old pipes used in making up the Pedal stops were similarly treated; that is, their toes were opened and nicking reduced.

Pipes voiced on pressures much over 70 mm. tend to become unsteady unless they are nicked, a process which as noted above, makes them less bright. It is possible to generate more power by increasing the pressure, but the timbre becomes less and less musical the more the pressure is increased. This is of no importance in the creation of whistles used for signaling such as those on ships and steam locomotives, but the matter of timbre certainly cannot be ignored in organs.

The plenum of the Swell division is less bright than that of the Great but not to the extent that there is a musical disparity between the two. The flutes of either division may be used to accompany the solo voices of the other. The Swell flutes accompany the Great Trumpet with as good a balance as the Great flutes accompany the cornet decomposée of the Swell. The Principal of the Swell is bright and clear, as is the Tierce. Those two stops added to the Great chorus give it a definite bite but do not add harshness. The Tierce if drawn in the chorus gives the illusion of having a light reed in the ensemble.

In the Pedal the Posaune delineates the line of any ensemble with which it is drawn. It serves that function in this relatively small organ much better than would a small mixture, and it has the added interest of providing a solo color that under certain circumstances may be used to very good advantage.

The organ in its revised state is designed to give solid support to the choir and congregation and to work well with soloists, both vocal and instrumental. While the most change of quality was between the old Great division and the new, there was no question that the other two divisions with their numbers of old pipes and chests were dramatically improved when their pipes were revoiced. To have rebuilt the organ in its previous style would only have changed a few dull basic timbres and improved nothing. The author recently heard a recital played on this rebuilt instrument that featured a number of different players, each of whom chose music and played in a style different from the others. The repertoire ranged from pre-Bach and Bach to contemporary music. Yet in my view nothing sounded uncharacteristic, and the most perceptive remark was perhaps an unsolicited one from a listener who commented that the organ "turned into a different instrument in the hands of each person who played it." It should be remembered that this organ is an instrument of only twenty-one ranks.

In spite of the scarcity of noteworthy organs and the fact that there are relatively few examples of fine voicing it would be unfair to say that the work of the majority of organ builders is of little value. Not all builders are equally skilled in voicing, and some builders seem not to have any good voicers, but among contemporary builders there are nevertheless a number of exceedingly fine musical craftsmen. My purpose is not to hold up anyone as a good or a bad example but to provide a little background to anyone who is sufficiently determined to become a good voicer. Organ builders on the whole in this country seem to agree that returning to traditional methods of design and construction was the correct thing to do. The return in recent decades of some major firms to the slider and pallet chest as their standard type of construction and to the use of tracker linkage whenever it is practical has been a welcome development.

Mention has been made previously in this chapter of the many smaller firms that build only tracker instruments. This is not to say that all of them are superior, but many of them are. In its own way the Casavant organ in the Church of the Assumption (Pl. I), Saint-Hyacinthe, Quebec, is a milestone. The firm had not built a tracker organ for about fifty years, and in order to build this organ in 1961 a builder was brought from Europe so that the technology of tracker organ construction could be re-established. The tonal director at the time was Lawrence Phelps, who in the space of less than a decade redirected the tonal philosophy of Casavant from what had been late bland post-Romantic drabness to the crisp and exciting timbres of earlier times. Concurrently many small groups of organ builders established shops that now produce instruments of exceptionally high quality and a diversity of styles—e.g., Fisk, Noack, Brombaugh, Andover, and Wolff, to name only a few.

It was the quality of voicing of these organs that brought about a gradual change in the way that voicers as a whole perceived the nature of their work. That change and the changing demands of discerning organists has had the effect of bringing about a return to the high standards of voicing of earlier times, and this has given vitality and meaning to the rediscovery of organ literature performance practices of past times. Just as the reintroduction of "period" instruments has enlivened our interest in music from before 1850, so also has the emergence of common voicing practice of that same era brought about a new way of listening to organs.

Glossary

Words defined elsewhere in this glossary are identified by an asterisk.

air reed: the vibrating sheet of moving wind (windsheet*) in front of the mouth of a flue pipe the motion of which excites the air in the body of the pipe into resonance.

antinode: of a sound wave, the point of least motion.

attack: the aggregate sounds generated by the opening of a valve under a pipe as it begins to speak.

bearing: temperament*.

block: the languid of a wood pipe.

body: that part of a pipe which contains the resonating air that generates its tone.

bright: the timbre of a pipe with fully developed upper partial tones.

burnisher: a hardened steel rod with a semicircular cross section, tapered to a blunt tip that is used to polish or impress a curve on reed tongues.

chiff: all of the transitory, non-harmonically related sounds produced by a flue pipe as it begins to speak, generally sounding like white noise*.

chorus: a collection of ranks within the same division of an organ of the same general timbre or class of tone.

cut-up: the vertical distance between the upper and lower lips of a flue pipe.

dead-length: cut to the exact length (of a flue pipe); a reed pipe with no provision for adjusting its length for regulation or tuning.

deutsche Orgelbewegung: the general descriptive term for any of several organ reform movements of the early quarter of the twentieth century.

dull: the timbre of a pipe with few or no upper partial tones.

ears: flat pieces of metal or wood flanking the mouth of a flue pipe to guide the sides of the windsheet*.

ensemble: the coherent sound made by a group of stops that are in the correct harmonic and tonal relationship with one another; the plenum of an organ, orchestra, or vocal chorus.

feathering: very fine nicking*, usually not visible to the unaided eye.

flexible wind: wind supplied to an organ that is deliberately balanced so that it fluctuates in a controlled fashion with varying demands.

flue: the open space between the front of the languid and the inside of the lower lip through which air escapes the foot to form the windsheet*.

foot: that part of a pipe which conveys the wind from the chest to the flue or to the motor of a reed.

formant: the harmonic spectrum of the timbre of a pipe.

halving ratio: the number that designates that pipe of a stop which is one-half the diameter of the first pipe of the series counting from the lowest note of the series; in the continental system, the first pipe of the series is not counted.

harmonic: a specific component of the whole series of vibrations above the fundamental frequency that make up the timbre of a note.

just intonation: a condition of tuning in which all members of a chord are harmonically related by small whole number fractions; without beats.

key channel: that portion of a windchest* into which air is admitted by the opening of a pallet and from which the pipes of any given note derive their wind.

lancette: an ornamental plasterer's trowel that has been cut square on both ends, thinned, and polished for use as a lip tool*; any thin blade that is used to slip into the flue of a pipe.

languid: the plate of metal dividing the body from the foot of a metal pipe, the front edge of which forms the rear surface of the flue.

lip tool: any of several shapes of flat metal tools used to pull out the upper or lower lip of a flue pipe.

loudness: the total amount of sound produced by a pipe; volume of sound.

mechanical action: any method of operating the valves of an organ windchest that is linked to the key in such a manner that the fingers of the player exert a direct pull to open the pipe valve or pallet without the intervention of an assisting mechanism.

mouth: the rectangular opening at the bottom of the body of a flue pipe across which the windsheet* moves.

mouth width: the ratio of the perimeter of a pipe to the width of the mouth expressed as a simple fraction.

mouthing mandrel: a tapered mandrel that has a flat area generated by a chord of its circle along one side so that at any point along its length the ratio between the circumferential segment and the chord is the same; used to form a correctly proportioned lower lip in the cone of metal that forms the foot of a pipe.

mouthing tool: mouthing mandrel*.

nicking: indentations in the leading edge of a languid or a block parallel to the flow of the windsheet*; the inner edge of the lower lip may also be so indented.

overtone: a partial tone of a note the frequency of which is a small whole multiple of the fundamental frequency.

pallet: a rectangular wood bar hinged and padded so that by the action of the key it opens or closes an opening to admit air to a key channel which supplies wind to the pipes.

partial tone: any of the several harmonically related components of the entire range of tones generated by a single pipe.

pouch: the flexible side of a sealed cavity either side of which is subject to an air pressure differential, the lateral action of which does the work required to open or close a valve or port.

pull-down: the wire connected to the pallet that extends through a gasket to link it with the tracker.

quick: the condition of pipe speech resulting from a languid that is too low or a reed tongue without sufficient curve so that the pitch of the pipe tends to settle on a harmonic rather than the fundamental pitch.

rank: a series of pipes in key sequence all of the same timbre.

register: an organ stop, of one or more ranks of pipes; that condition of wind holes being in or out of alignment, when in alignment permitting air to flow past a slider into pipes to make them speak.

skive: the operation of tapering the edge of a piece of leather to a feather edge by shaving it with a sharp knife against a smooth stone surface.

slider: a thin, flat strip of material bored with holes which coincide with the toes of pipes that can be slid out of register so that the holes are blocked or not at will.

slot: a rectangular opening cut in the body of a pipe near the top (1) for the creation of a tuning roll, (2) for regulation of loudness of a reed stop, or (3) for stability of tone of a narrow scale flue stop.

slow: the condition of pipe speech resulting from a languid that is too high, or from a reed tongue with too great a curve or excessive weight which causes the attack of the note to lag.

solenoid: an electromagnet that operates a pipe valve or pallet in a windchest.

Stimmschlitz: a tuning slot*.

stop: a series of pipes, one or more for each key, under the control of a single drawstop or tablet.

swage: to re-shape metal by turning it inward by squeezing with a conical tool.

temperament: a system of frequency values for each note of a scale the intervals of which deviate from just intonation.

timbre: a term which implies the precise harmonic spectrum of a pipe; the exact tone color of a pipe.

toe board: the board upon which the pipes of a stop or register stand having holes through which the air passes to make the pipes speak, either placed directly over the slider or connected with tubing to the appropriate slider.

tone color: timbre*.

tracker: a long, thin strip of straight-grain wood used to exert a pull over a long distance for the purpose of connecting the pallets to the keys of an organ.

tuning iron: tuning tool*.

tuning roll: the rolled up metal within a Stimmschlitz*.

tuning slot: a rectangular opening cut into the top of a pipe, the metal of which is rolled up for tuning purposes; a Stimmschlitz*.

tuning spring: tuning wire*.

tuning tool: a bar or stick of metal shaped so that it has smooth, square edges and is balanced to fit the hand, used to raise or lower tuning collars or reed tuning wires.

tuning wire: a piece of spring metal shaped to slide freely through the block of a reed pipe to bear against the tongue to keep it in contact with the shallot; usually notched or curved at its top to engage the tuning iron.

variable scale: a scale that deviates from a simple logarithmic progression in an irregular fashion.

voice: (n.) a series of pipes under the control of a single drawstop or tablet with one or more pipes per key of the same timbre; (v.) to manipulate a pipe so that it will consistently produce its intended pitch and timbre.

white noise: a sound composed of all pitches, therefore having no definite pitch of its own.

windchest: a shallow, airtight wooden box that contains wind at the correct pressure for pipe speech and the mechanism necessary for their control.

windsheet: the moving body of air that passes across the mouth of a pipe, so-called because it is very thin relative to its width and height; air reed*.

windway: that part of a flue pipe that contains and shapes the windsheet*.

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In no sense should this bibliography be regarded as complete; rather, it is a listing of suggested reading in some of the basic sources for background and historical detail. For additional references through the mid-1970's, see the bibliography appended to the *New Grove* article by Peter Williams; for later items, see Peter Williams and Barbara Owen, *Organ*, a book derived from the *New Grove* and published in 1988.

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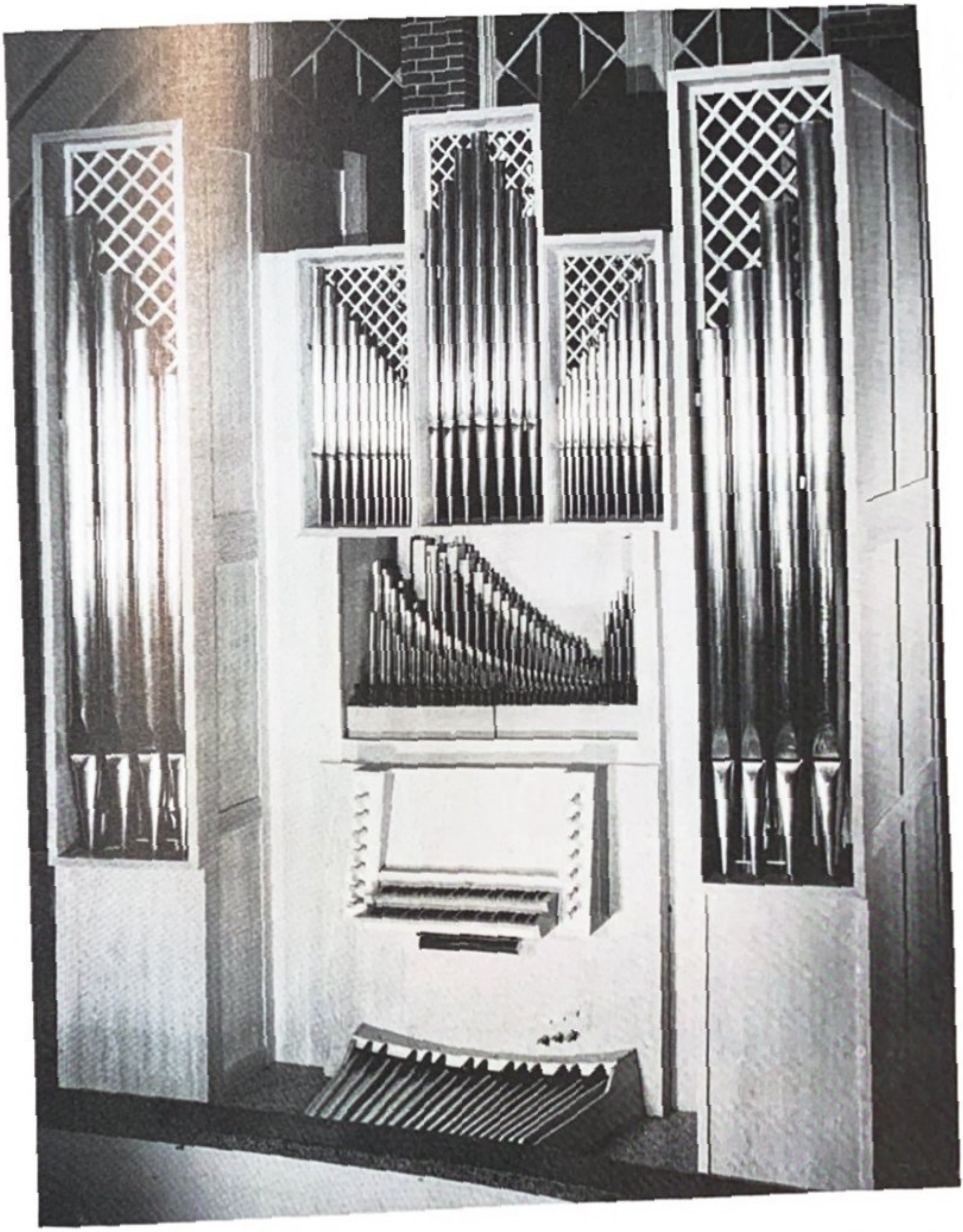
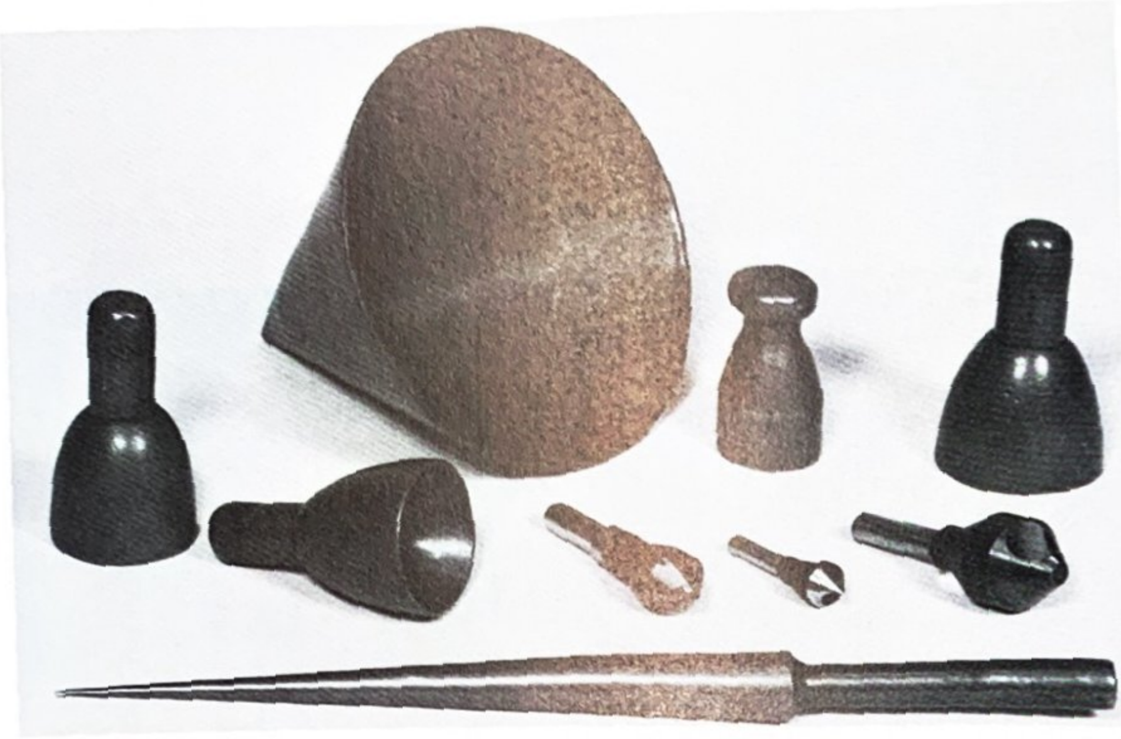
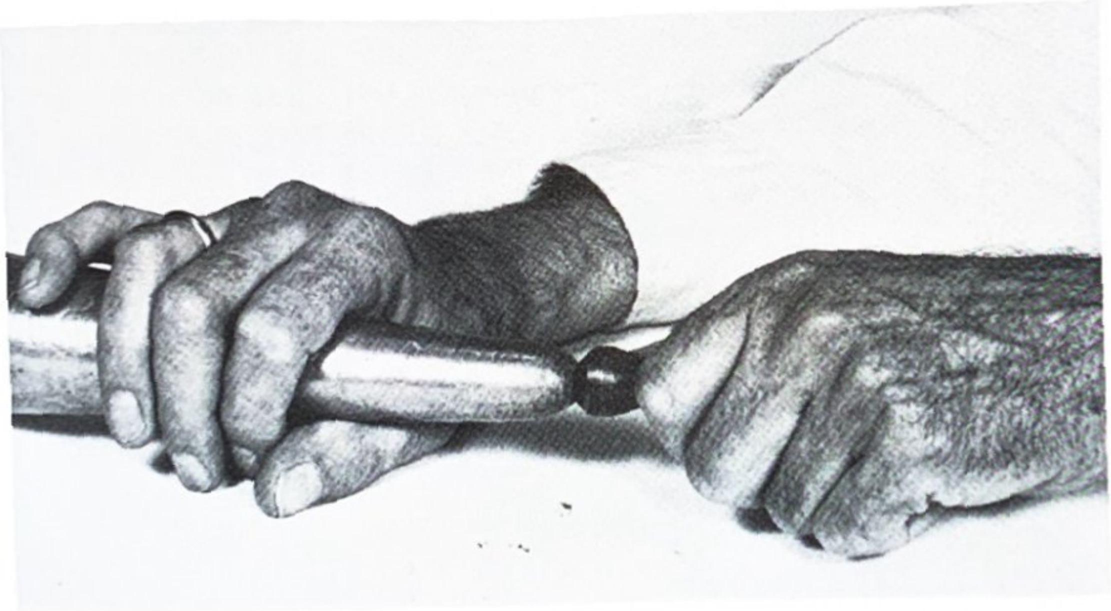


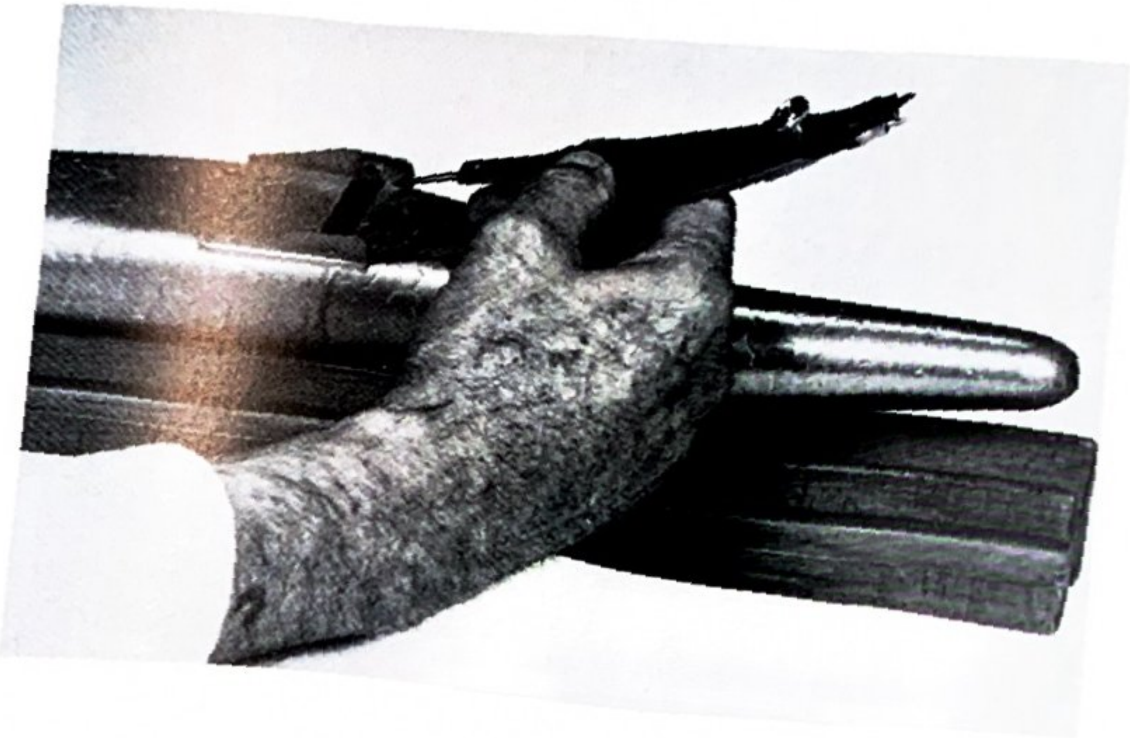
I. The first modern Casavant tracker organ, 1961. Church of the Assumption, St. Hyacinthe, Quebec. Photo: Studio Lumière.



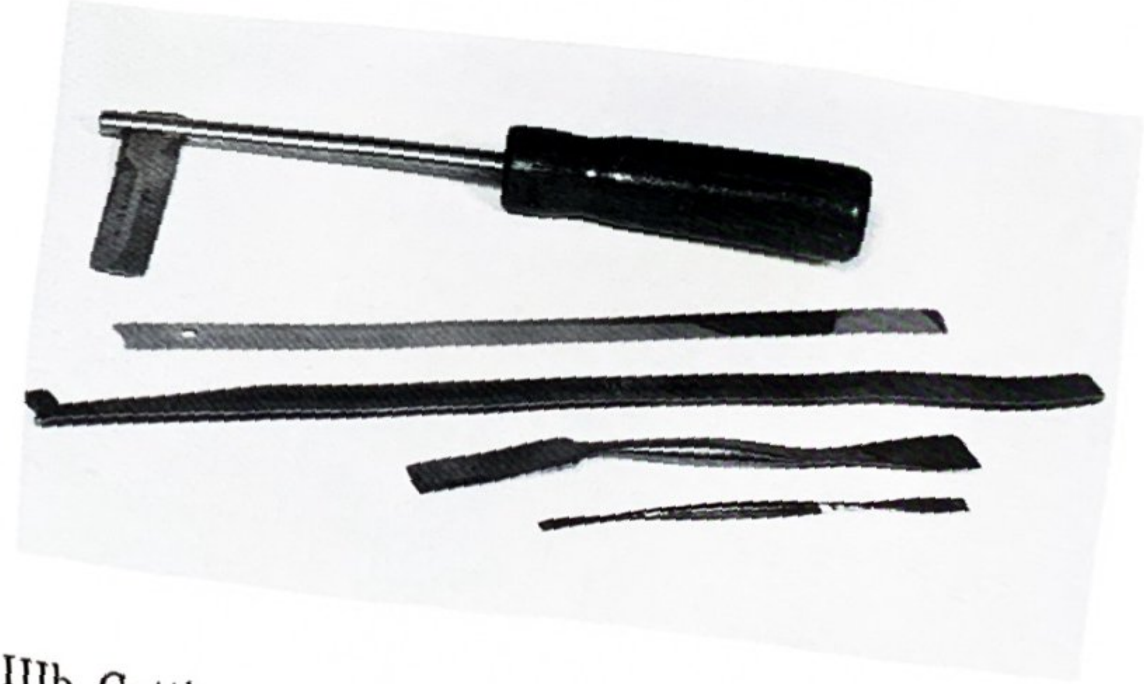
IIa. Toe cones, countersink bits, foot hole gauge.



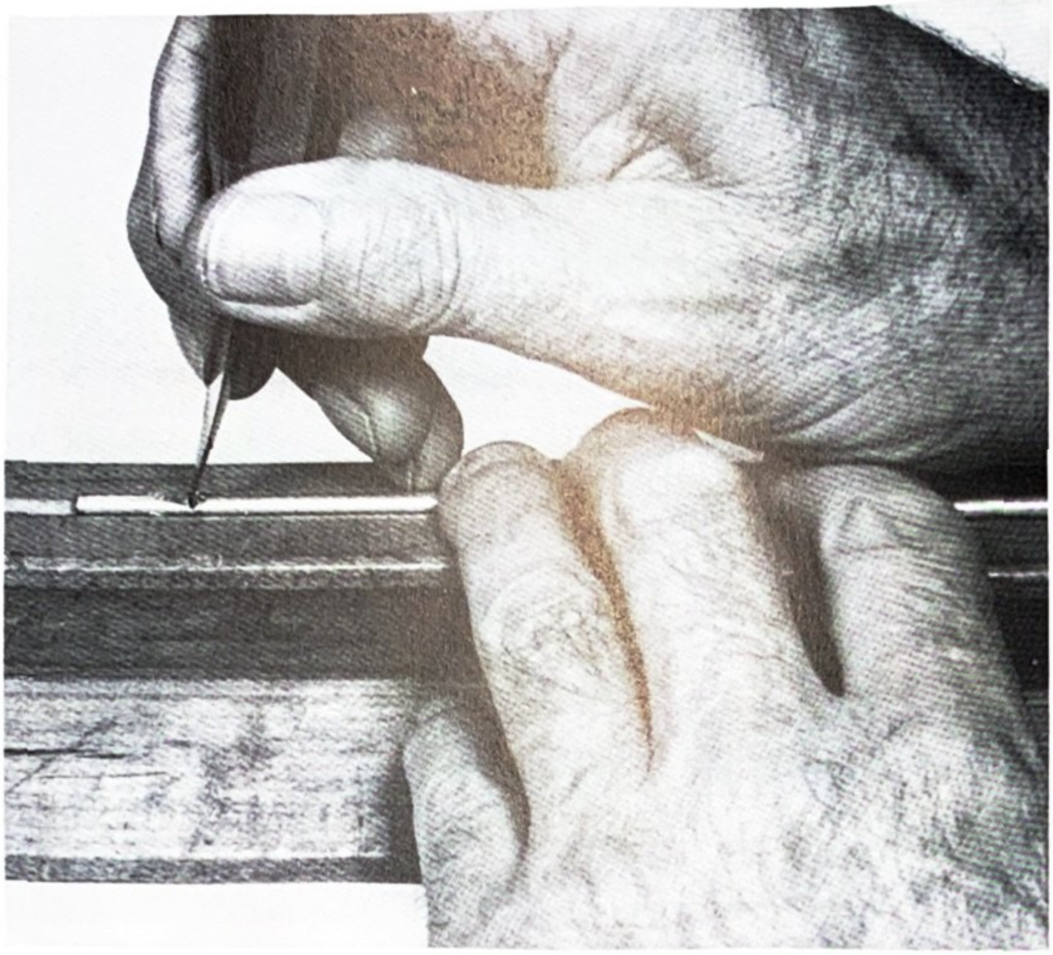
IIb. Making a countersink in a toe pipe.



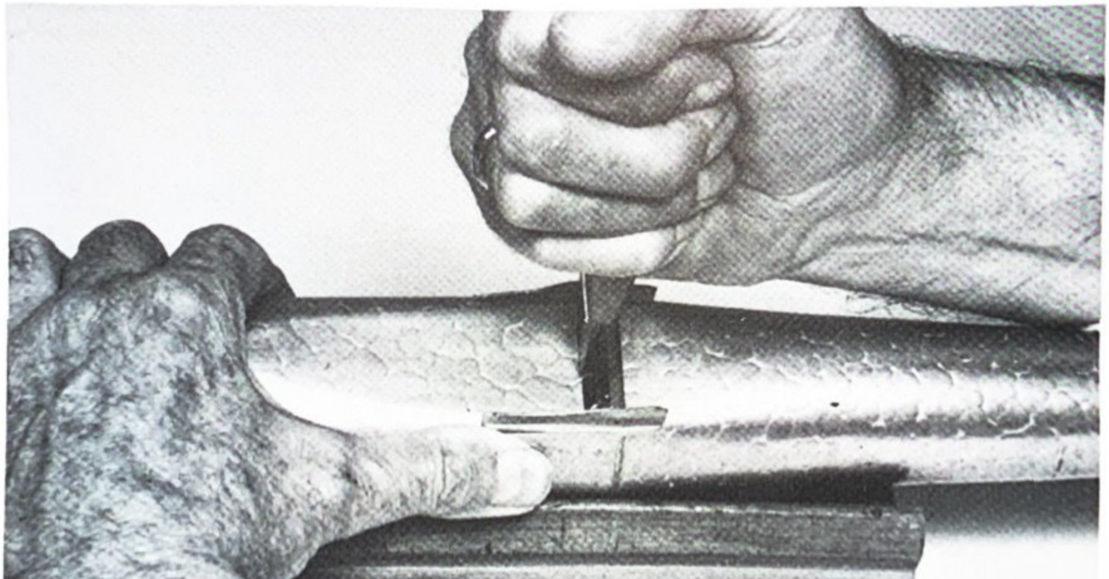
IIIa. Marking the cut-up of a pipe.



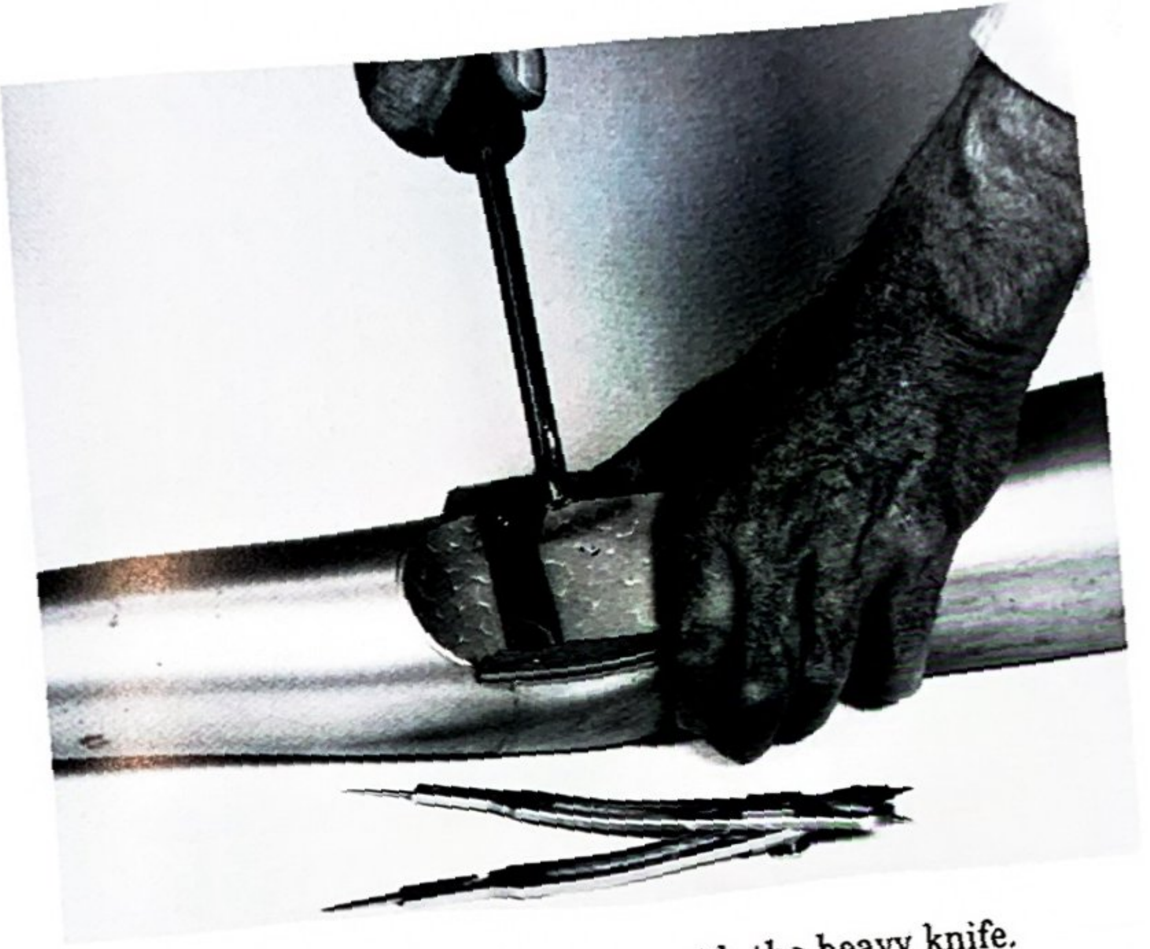
IIIb. Cutting-up knives, lancette, and tuning tools for reeds and slide tuners.



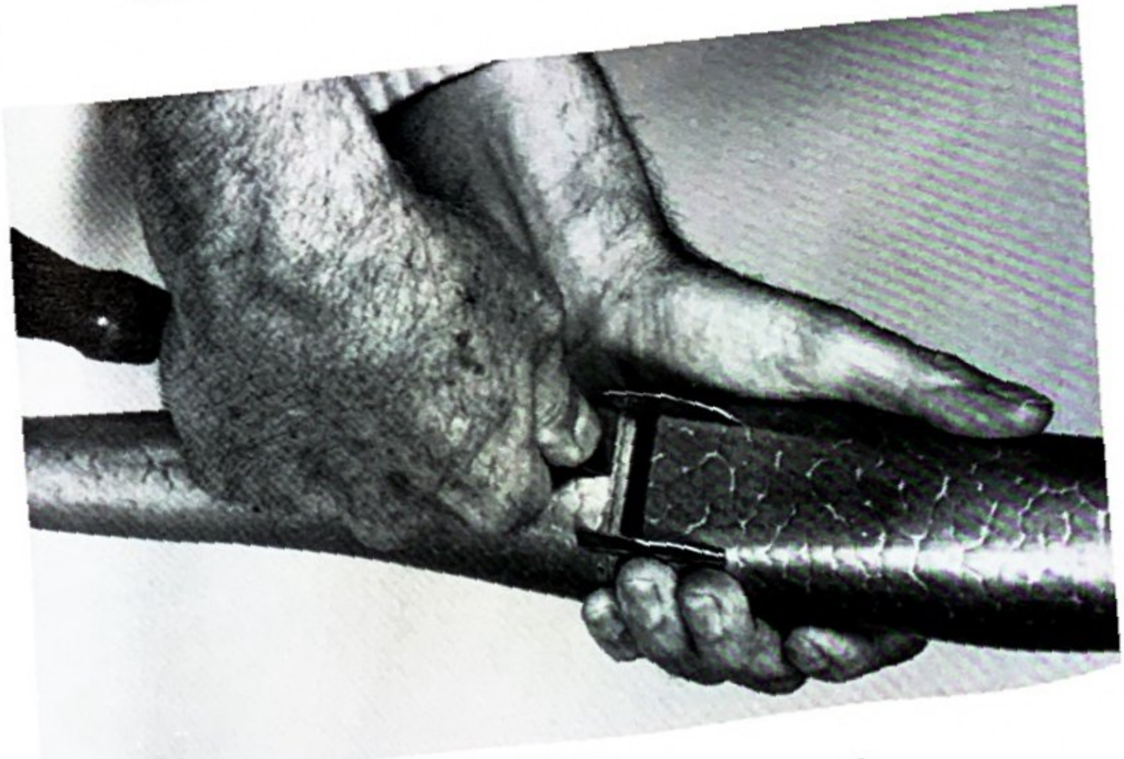
IVa. Cutting up a very small pipe.



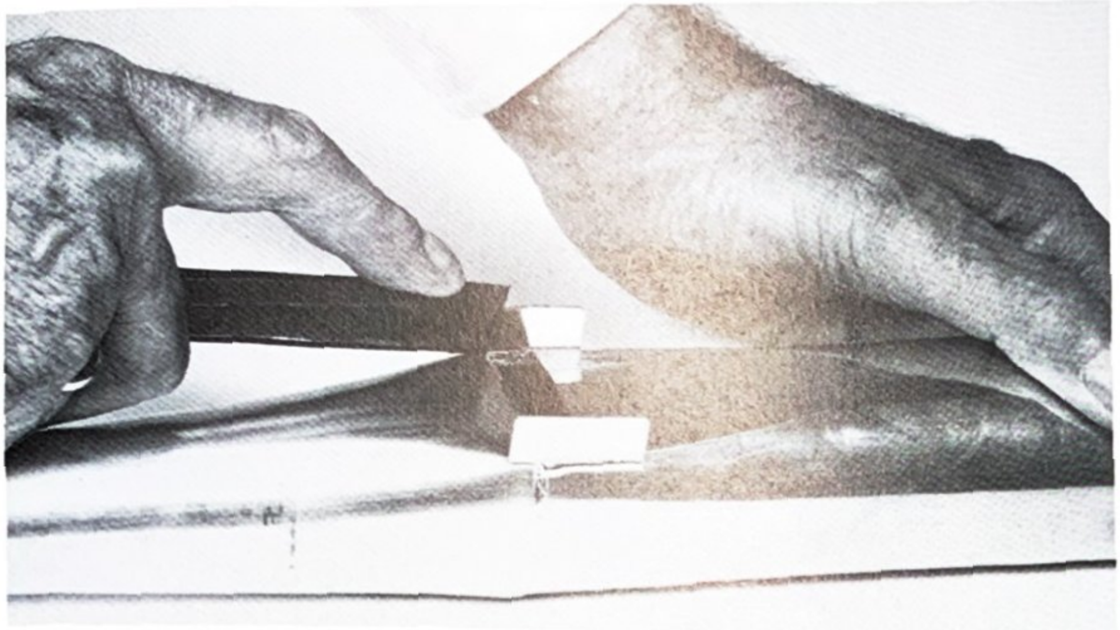
IVb. Cutting up a c′ pipe.



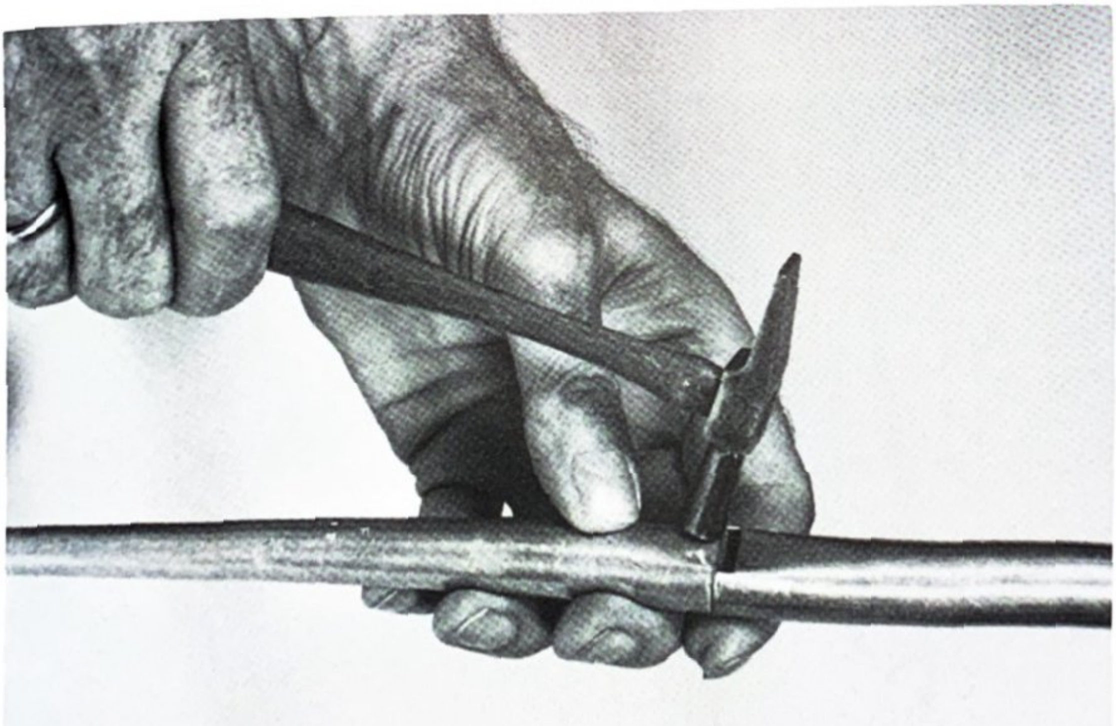
Va. Cutting up a bass pipe with the heavy knife.



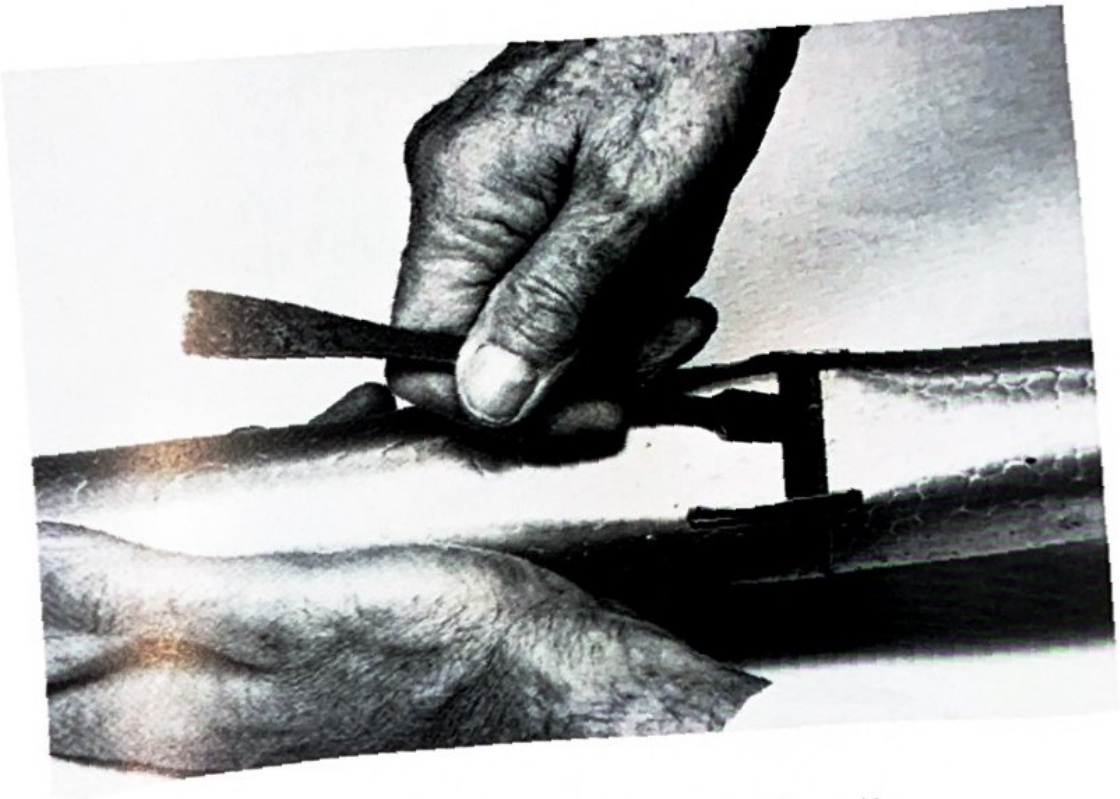
Vb. Closing a flue with a flat tool.



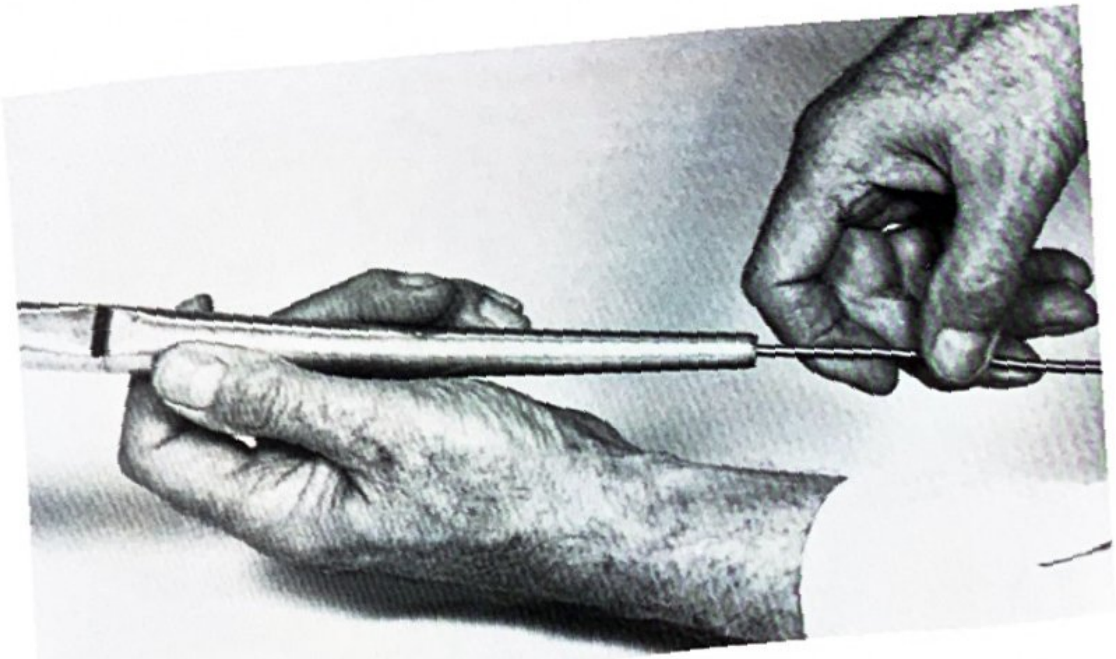
VIa. Closing the corner of a flue with a chisel.



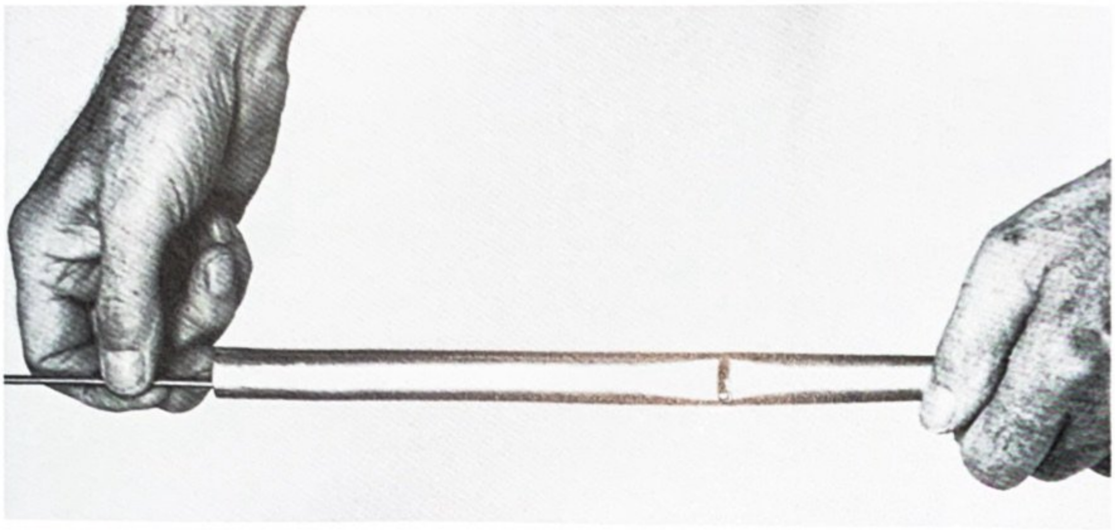
VIb. Closing a flue with a small hammer.



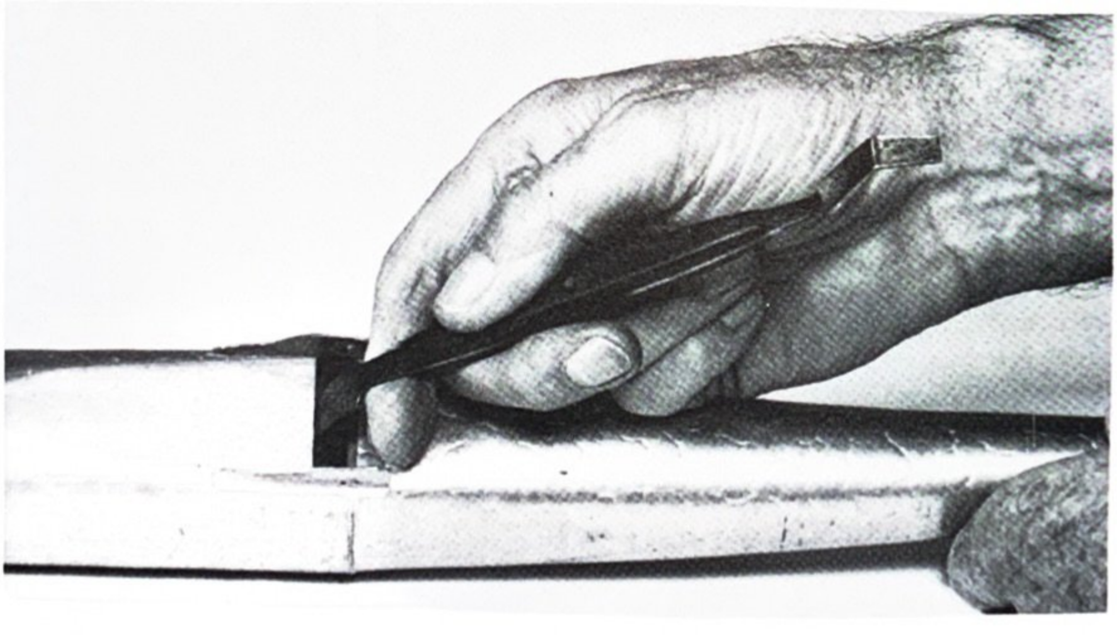
VIIa. Opening a flue with a lancette.



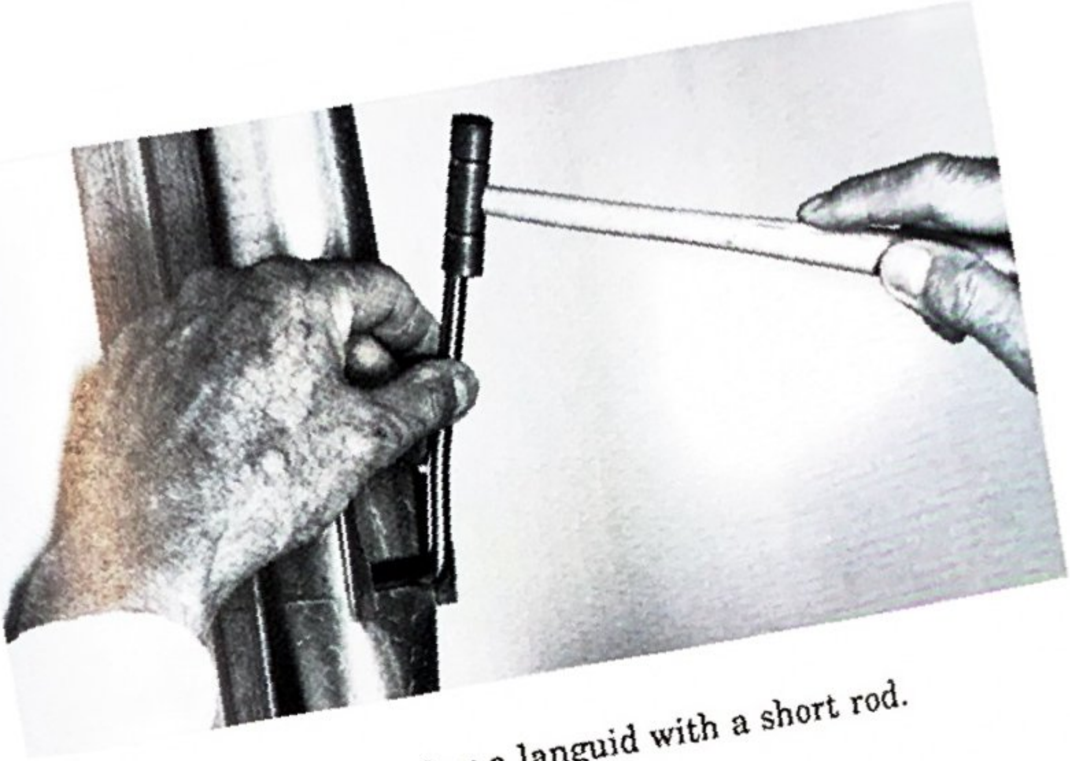
VIIb. Raising a languid with a rod.



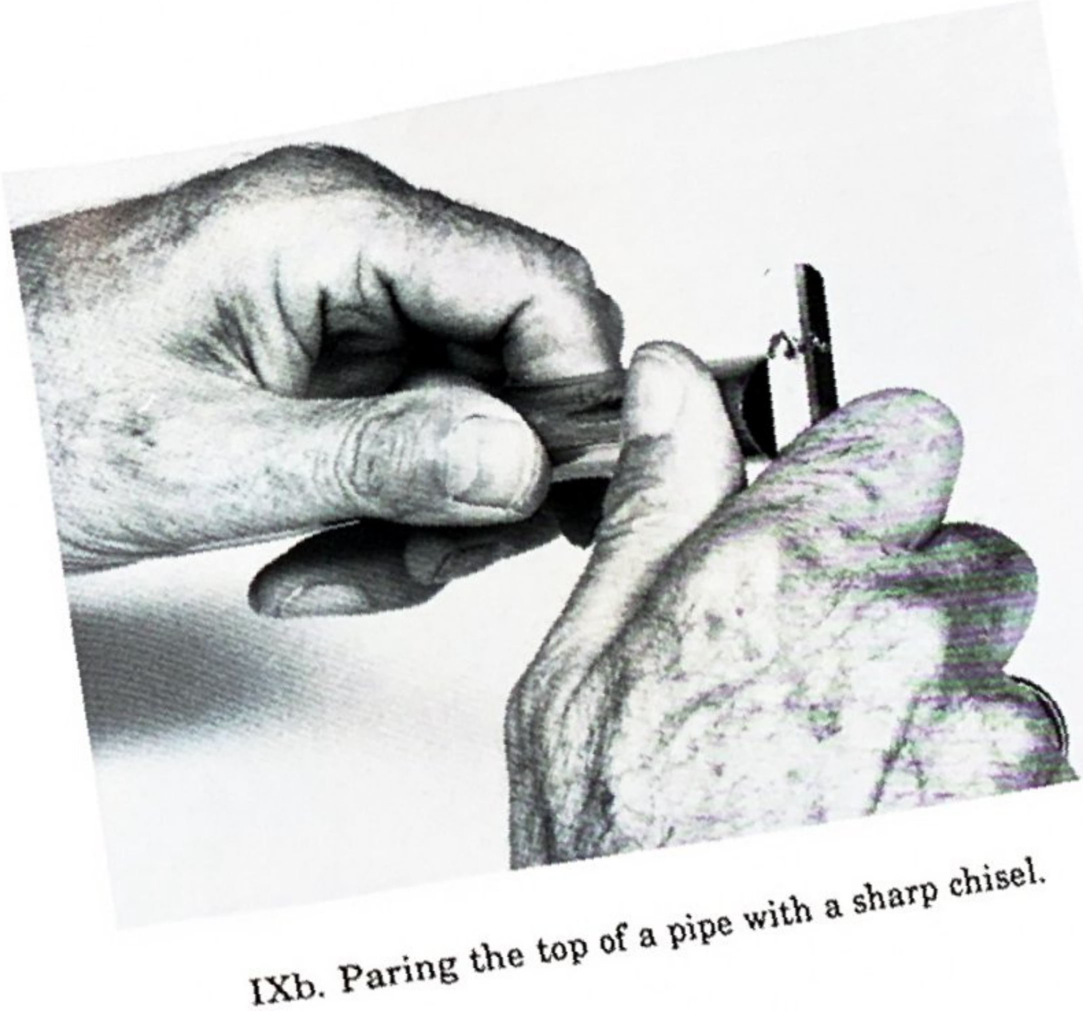
VIIIa. Lowering a languid with a rod.



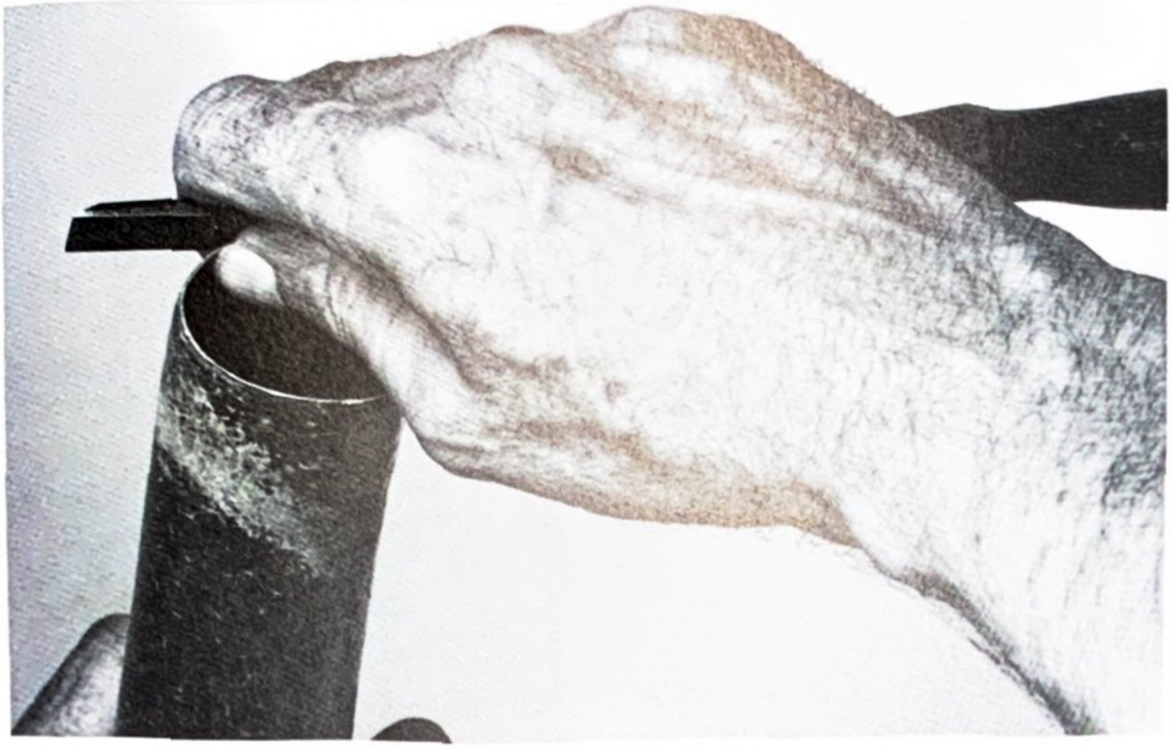
VIIIb. Pulling out a lip with the lip tool.



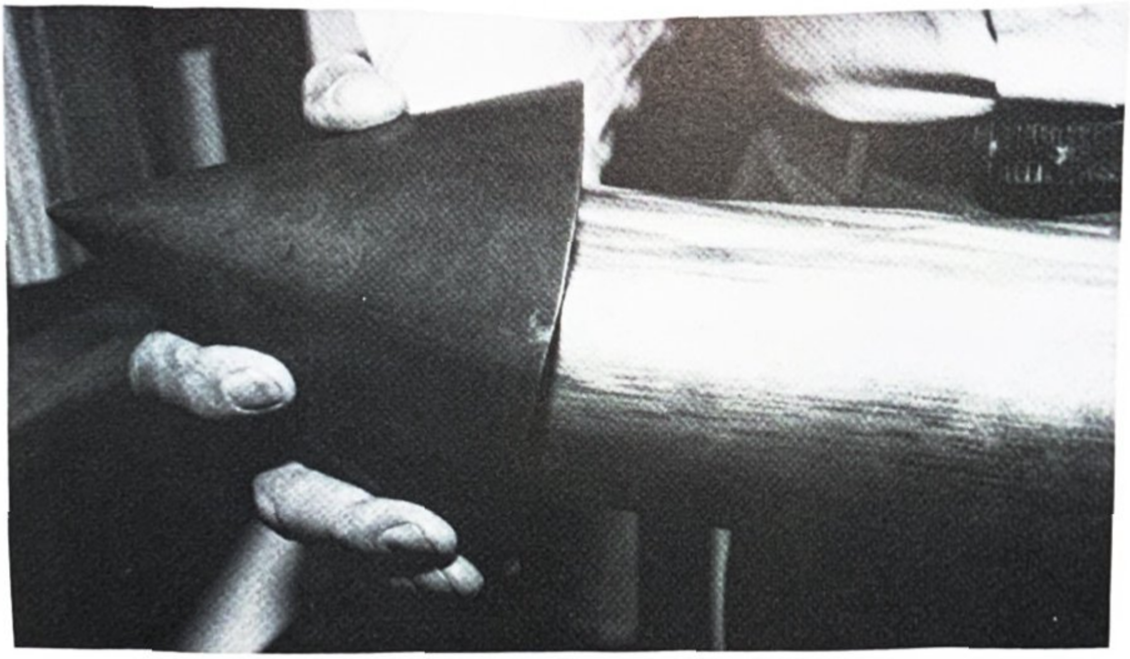
IXa. Lowering a languid with a short rod.



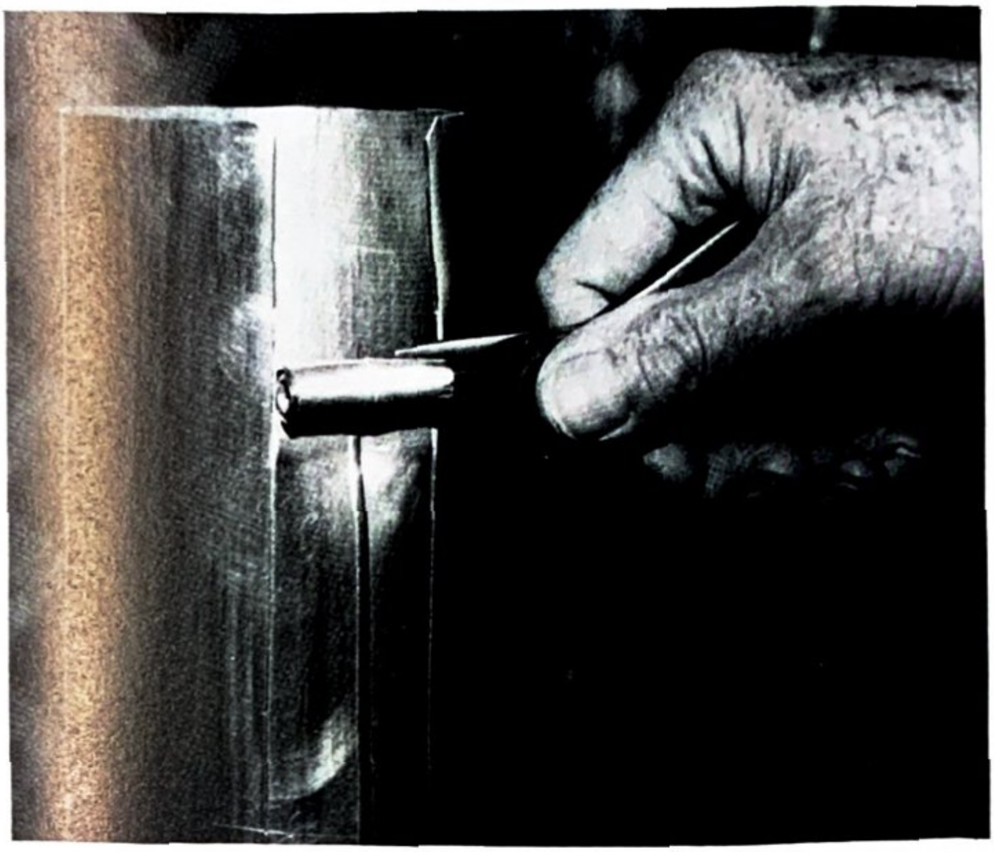
IXb. Paring the top of a pipe with a sharp chisel.



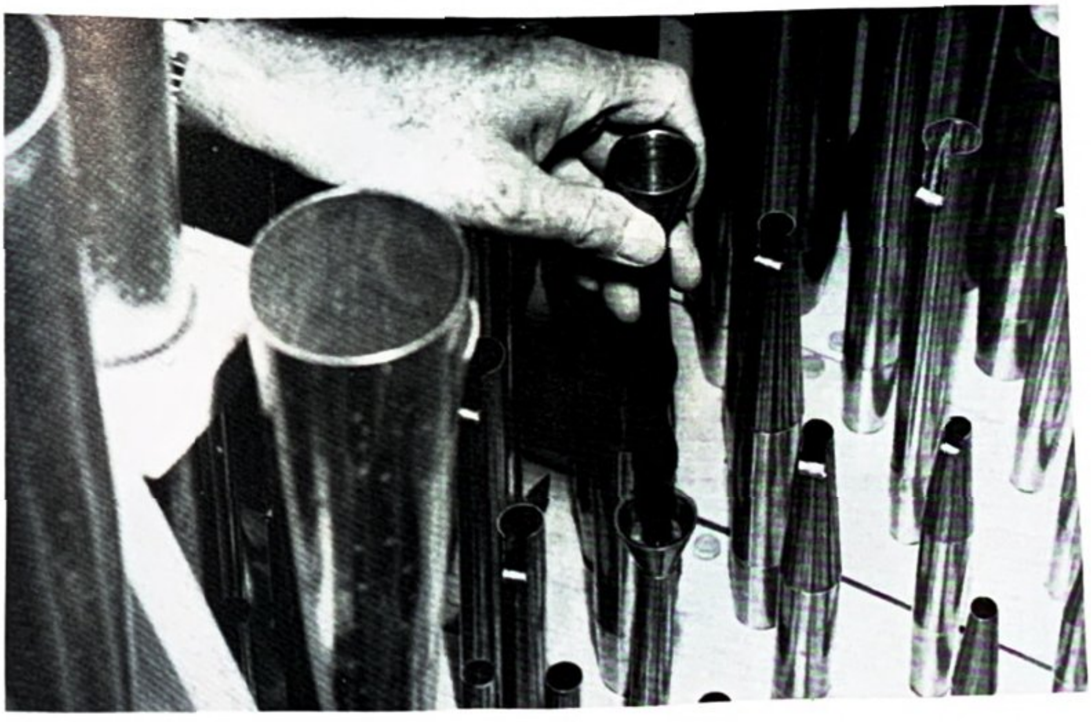
Xa. Swaging the top of a large pipe.



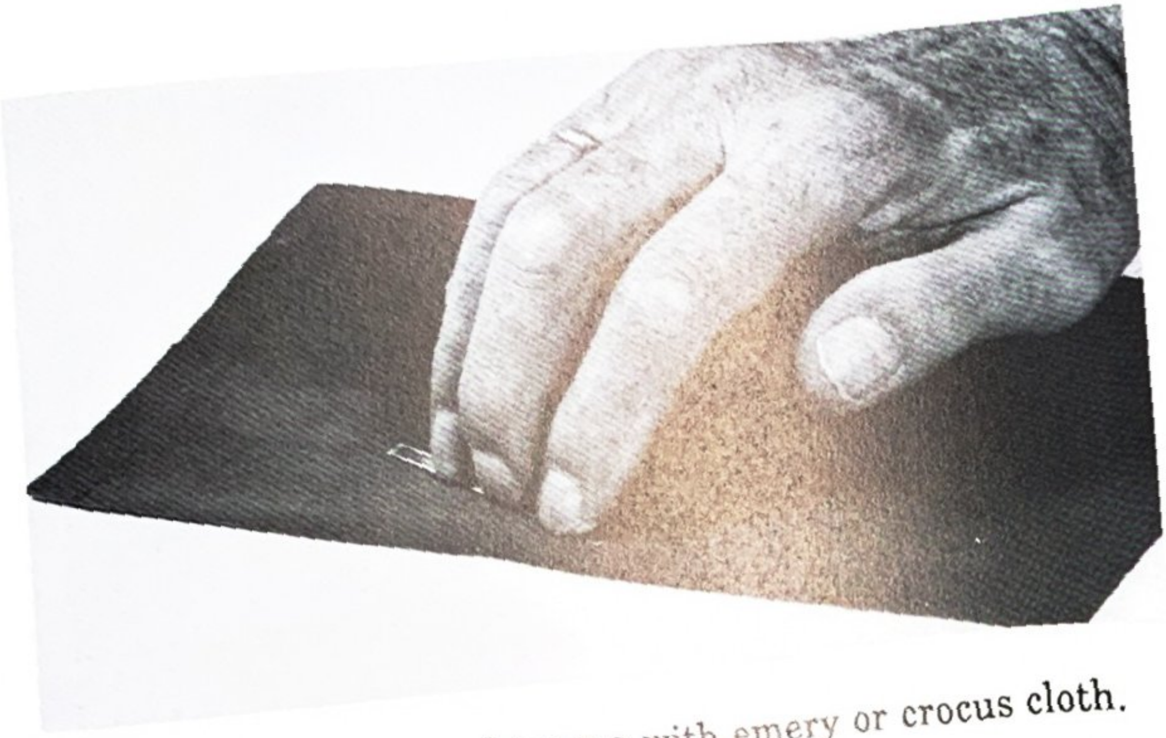
Xb. Rounding the top of a large pipe with a cone.



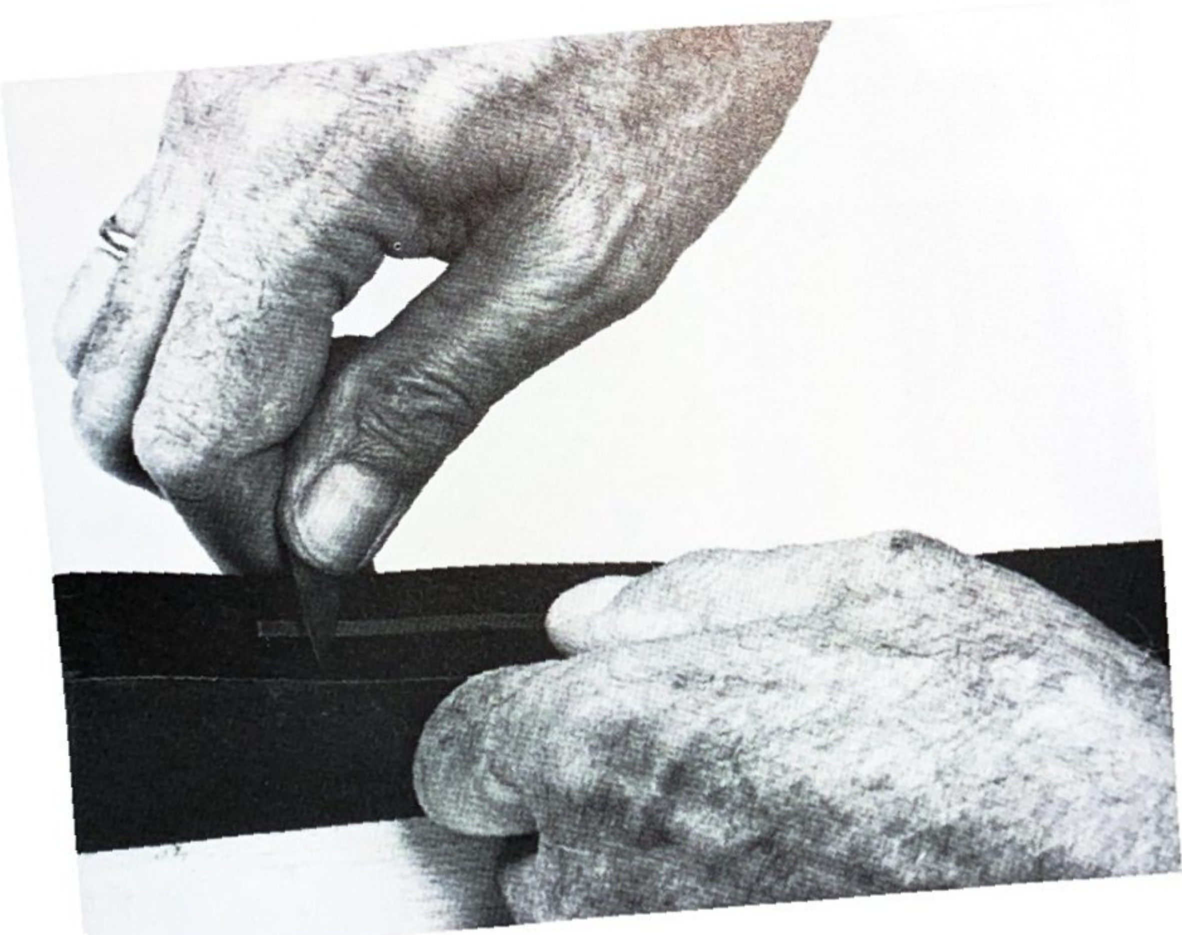
XIa. A tuning roll and how it is moved with pliers.



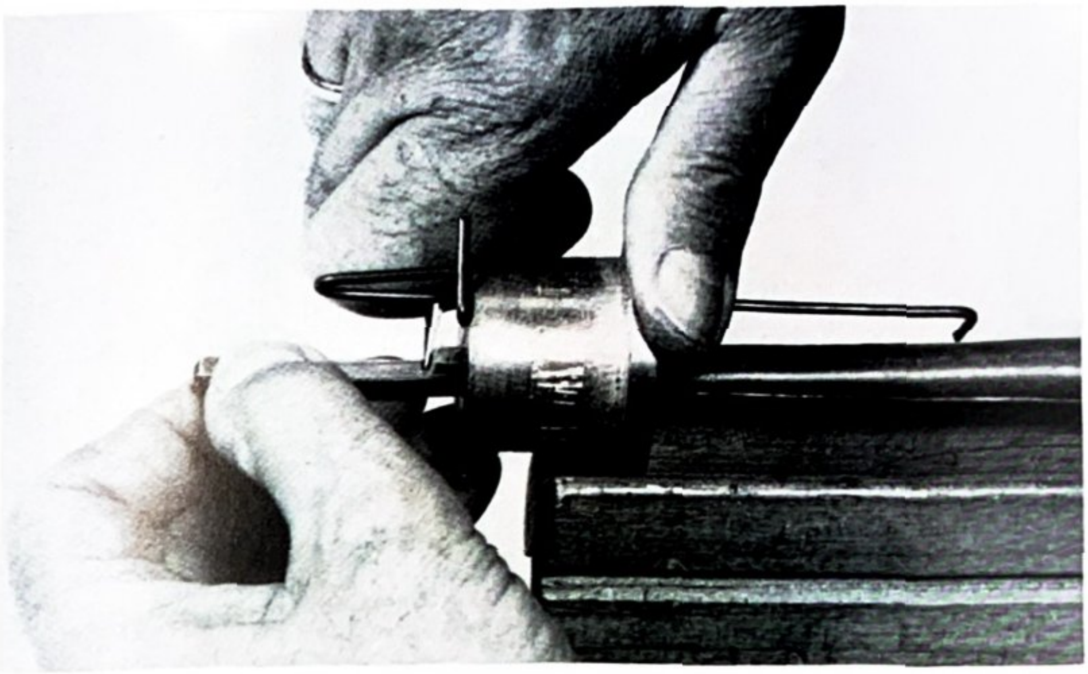
XIb. Using a small tuning cone.



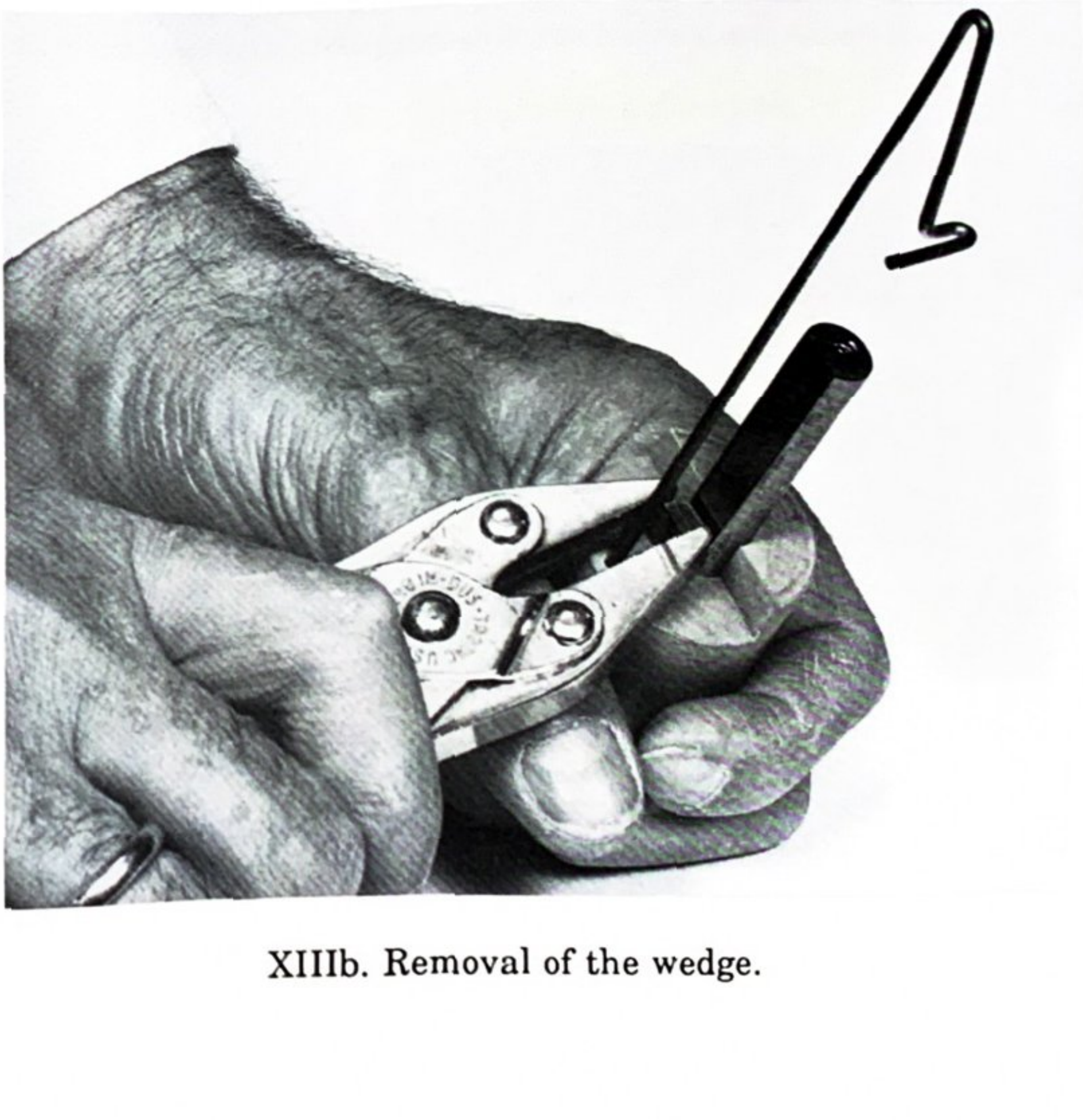
XIIa. Polishing a reed tongue with emery or crocus cloth.



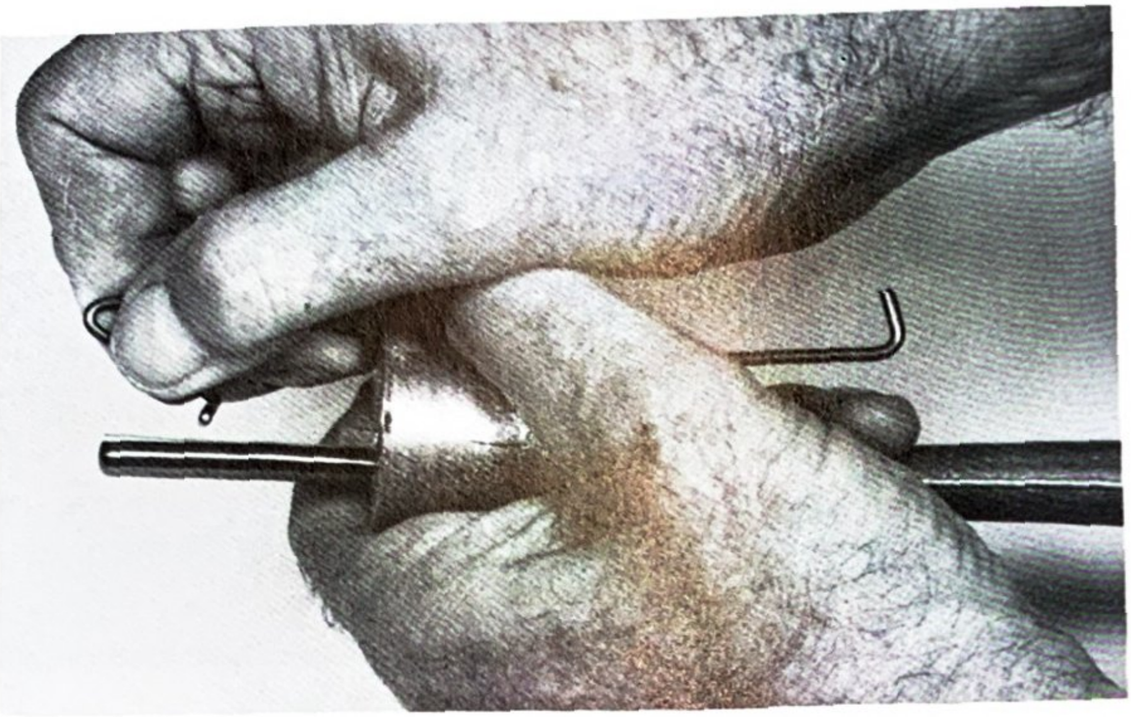
XIIb. Using a curving block.



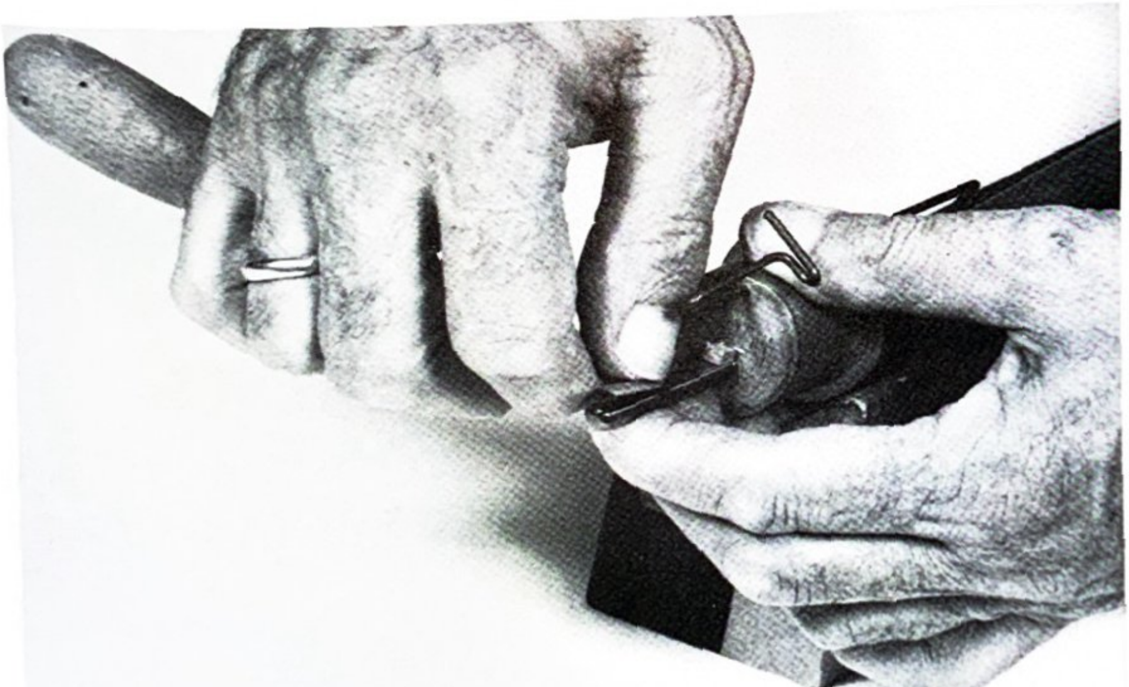
XIIIa. Seating the wedge.



XIIIb. Removal of the wedge.

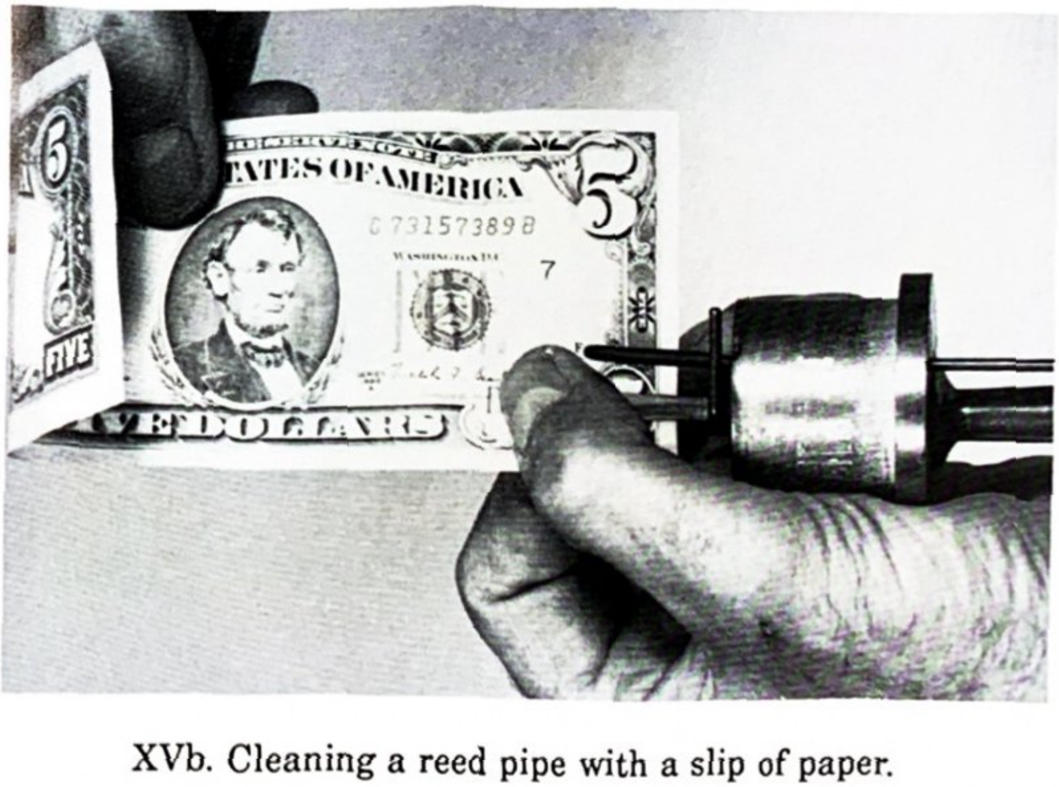


XIVa. Tuning wire pulled away from the tongue and shallot.

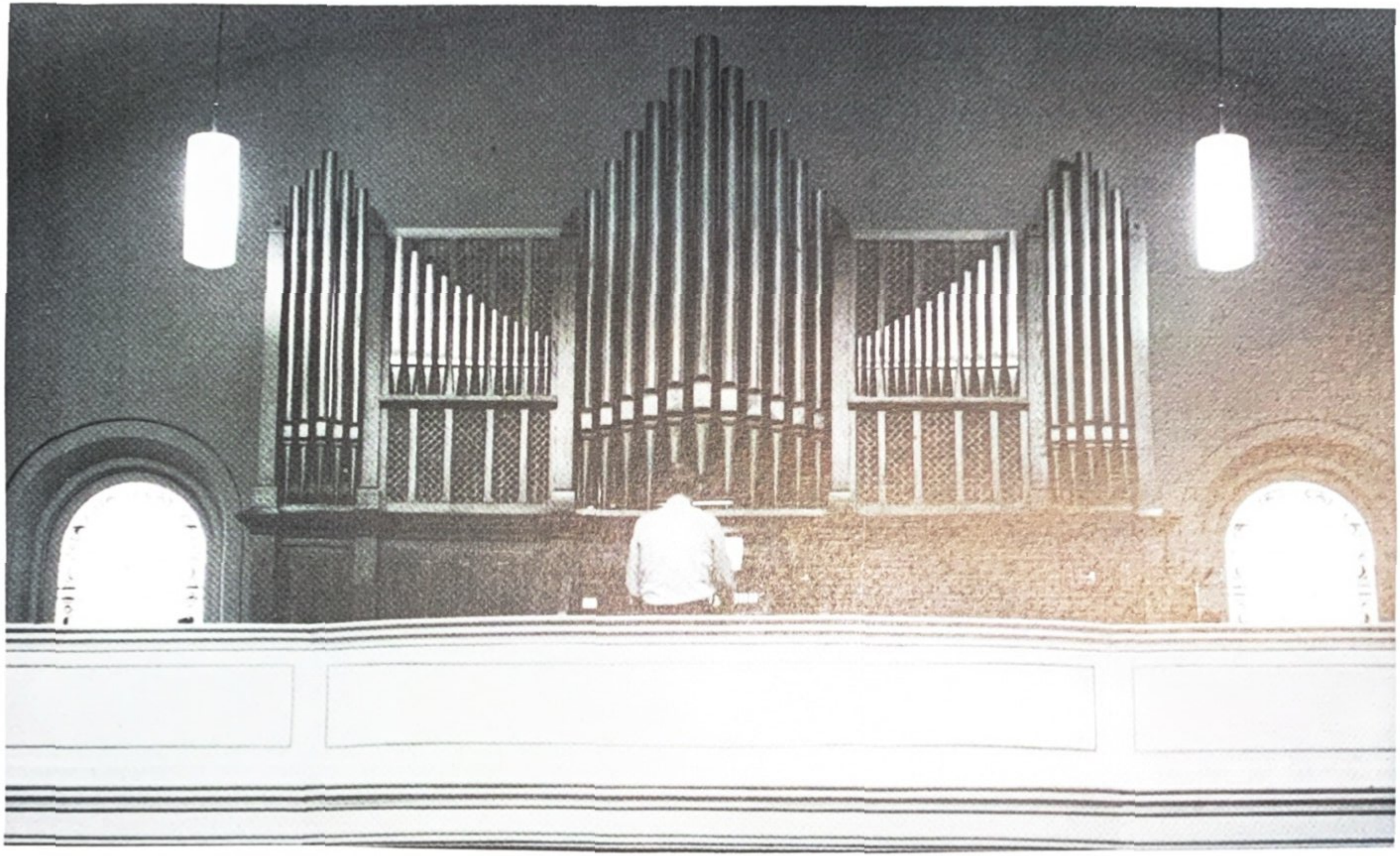


XIVb. Curving a tongue with a knife blade.

XVa. Tuning with a reed tool.



XVb. Cleaning a reed pipe with a slip of paper.



XVI. Façade of the organ in St. Norbert Church, Roxbury, Wisconsin.